FISHERY MANAGEMENT INVESTIGATIONS

# IDAHO DEPARTMENT OF FISH AND GAME

# FISHERY MANAGEMENT ANNUAL REPORT

**Virgil Moore, Director**

## SOUTHEAST REGION
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# LOWLAND LAKE AND RESERVOIR INVENTORIES AND SURVEYS


## ABSTRACT

Johnson Reservoir was identified as an under-performing fishery in 2010. In 2011, 2012 and 2013 we stocked a total 169 Largemouth Bass *Micropterus salmoides* (LMB) over 270 mm in an attempt to improve the size structure of the Bluegill *Lepomis macrochirus* population found there. Our results show that Bluegill proportional stock densities (PSD) increased from 2 in 2010 to 40 in 2013. Likewise LMB PSD increased from 12 to 17 during the same time frame. Largemouth Bass PSD was also evaluated in four additional Franklin County reservoirs. Condie Reservoir had the highest LMB PSD estimate of 88 followed by Glendale (60), Twin Lakes (45), Johnson (17) and Lamont (11). Double-crested Cormorants *Phalakros auritus* (DCC) caused significant losses of hatchery Rainbow Trout *Oncorhynchus mykiss* (RBT) in Foster, Glendale and Treasureton reservoirs.We estimated at a minimum, 4,120 RBT were consumed by DCC in 2013 at a production cost of about $10,300. The American White Pelican *Pelecanus erythrorhynchos* and DCC continue to cause significant losses of hatchery RBT stocked into Chesterfield Reservoir. In 2013, we determined that the vast majority of RBT were consumed by DCC. Based on the raw tag recovery rate, we estimated the loss of RBT to be about 11,145 at a production cost of about $27,862. To reduce this loss, we plan to stock RBT in the spring of 2014; just after ice out but before the piscivorous birds arrive at the reservoir. We think this approach will give the fish a chance to acclimate to their new environment which may reduce their vulnerability to predation.

## Johnson Reservoir

### Introduction and Methods

Johnson Reservoir is located in Franklin County near Preston, Idaho. When full, Johnson Reservoir covers approximately 20 hectares and has an elevation of 1,485 meters. The reservoir is used primarily for irrigation storage and provides angling opportunities for Largemouth Bass *Micropterus salmoides* (LMB), Bluegill *Lepomis macrochirus* (BG), Yellow Perch *Perca flavescens* and Rainbow Trout *Oncorhynchus mykiss*. Tiger muskellunge *Esox lucius x E. masquinongy* were stocked in the past to provide a trophy component and to help reduce over-abundant BG less than 170 mm. The tiger muskellunge program, however, was criticized by anglers and was subsequently discontinued.

During 2010, we identified Johnson Reservoir as an underperforming fishery due its high catch rates of small BG. Over the past decade, BG Proportional Stock Density (PSD) has been well below what should be observed in a balanced population (50%-80%; Table 1). In an attempt to improve the size structure of the BG fishery, we began transferring LMB into Johnson Reservoir to increase predation on the BG population. During 2011, 2012 and again in 2013, we collected LMB from surrounding Franklin County reservoirs and relocated them to Johnson Reservoir. All LMB transferred to Johnson were large enough (≥ 275 mm) to be effective predators on juvenile BG at the time of stocking.

Largemouth Bass and BG populations were monitored using boat mounted electrofishing gear. All fish captured were weighed and measured to the nearest gram and millimeter (total length) and released. All electrofishing surveys were conducted at night during the latter part of June. To avoid sampling newly stocked LMB, all surveys were conducted prior to LMB transfers each year.

### Results and Discussion

The predator enhancement program appears to be having the desired impact on improving the PSD of BG. In 2010 and 2011 (prior to the implementation of this project) the BG Proportion Stock Density (PSD) was two and six percent, respectively. In 2012, the BG PSD increased substantially to 31% and again to 40% in 2013; the highest PSD observed during historical sampling (Table 1). Similarly, the length frequency distribution observed in 2013 shows modest improvement over what was observed in the previous three years (Figure 1). However, the current BG PSD (40%) is still below the desired range. Both Guy and Willis (1990) and Novinger (1978) suggest a BG PSD of 40%-60% is needed to spark angler's interest in the fishery. However, Gabelhouse (1984) suggests that a BG PSD of 50%-80% is needed to promote a high level of angler participation in the fishery.

Bluegill relative weight ($W_r$) declined in 2013. In both 2010 and 2011 BG $W_r$ was similar at 87%. In 2012, BG $W_r$ increased to 98%; significantly higher than in either of the previous two years (ANOVA; F=56.261; df=2; P<0.0001). However, $W_r$ significantly decreased to 93% in 2013 (F=26.213; df=3; P=0.000). Even though $W_r$ declined to 93%, that value indicates good body condition and appropriate abundance for the available habitat.

Table 1. Electrofishing catch-per-unit-effort (fish/hr) of Largemouth Bass (LMB) and Bluegill (BG) from Johnson Reservoir during 2010, 2011, 2012 and 2013. Proportional Stock Density values are shown in parenthesis.

| Species | 2002 | 2006 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| LMB | 54 (7) | 20 (0) | 108 (12) | 217 (26) | 179 (17) | 170 (17) |
| BG | 305 (24) | 240 (10) | 297 (2) | 417 (6) | 1,004 (31) | 757 (40) |

Historically, LMB PSD has been low in Johnson Reservoir. Largemouth Bass PSD has not reached at least 40% (Ideal range 40%-60%) in the last 10 Years (Table 1). Chronically low LMB PSDs likely explain the imbalance in the BG population. High catch rates of small bluegill are often associated with low numbers of quality-sized (280 mm) or greater Largemouth Bass. Insufficient predation from Largemouth Bass often results in lower Bluegill PSD values.

Largemouth Bass were transferred in June of 2011, October of 2012 and again in June of 2013. On 27-June, we transferred 33 LMB collected from Glendale Reservoir to Johnson Reservoir. These LMB had a mean length and weight of 378mm and 805g, respectively. Size of LMB transferred to Johnson Reservoir in previous years is presented in Table 2.

Table 2. Number, mean total length (mm) and mean weight (g) of Largemouth Bass transferred to Johnson Reservoir by year.

| Year | Number | Length (mm) | Weight (g) |
|---|---|---|---|
| 2011 | 114 | 380 | 726 |
| 2012 | 22 | 292 | 502 |
| 2013 | 33 | 378 | 805 |

In summary, the BG population in Johnson Reservoir appears to be responding positively to augmentation of LMB. However, LMB PSD remains well below objective. A polymodal size structure is indicative of a population not over exploited by anglers. However, the LMB population in Johnson Reservoir shows a unimodal size distribution (Figure 2), which indicates the LMB fishery is over exploited (Beamish et al. 2006). To help compensate for angler exploitation, we will increase our efforts and transfer 100-200 LMB in 2014.

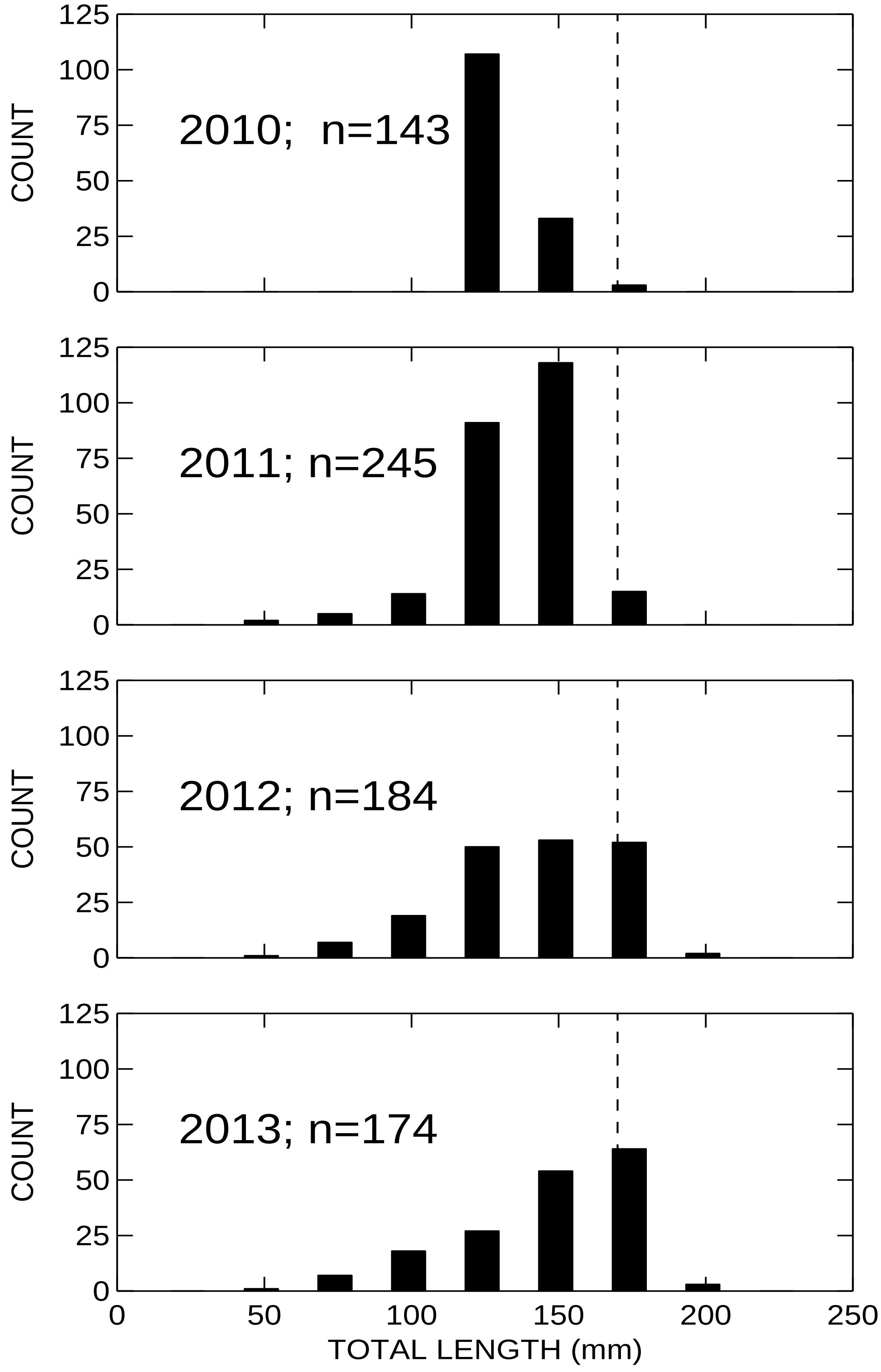


Figure 1. Length frequency distribution of Bluegill collected from Johnson Reservoir, Idaho, in 2010, 2011, 2012 and 2013. Vertical dashed lines at 170 mm represent quality size or larger Bluegill.

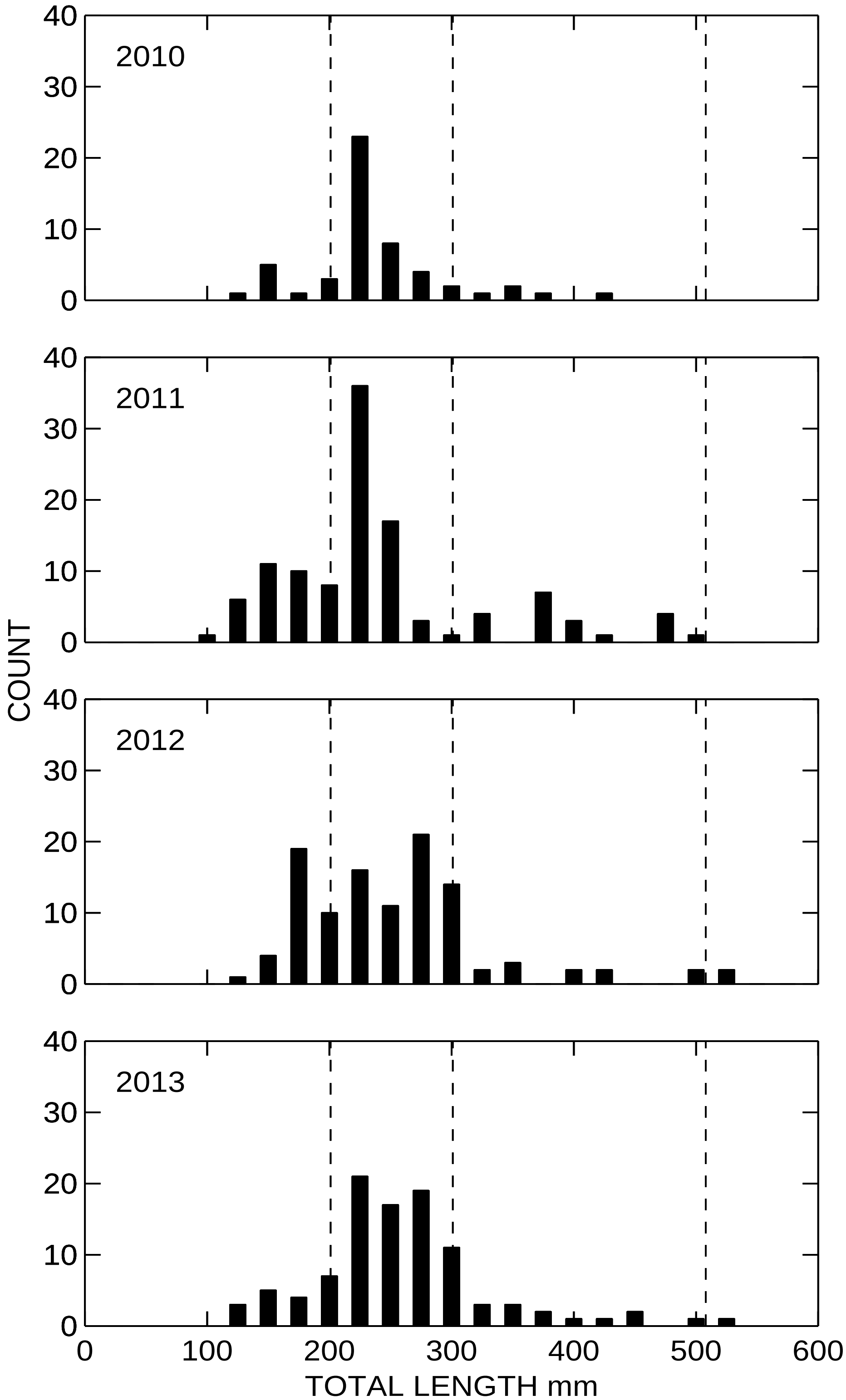


Figure 2. Length frequency distribution of Largemouth Bass collected from Johnson Reservoir, Idaho, in 2010, 2011, 2012 and 2013. Vertical dashed lines at 200 mm, 300 mm and 510 mm represent stock, quality and trophy sizes, respectively, for Largemouth Bass.

## Largemouth Bass Surveys

### Introduction and Methods

In the early 1990's a comprehensive research study was initiated to better understand the biology of Largemouth Bass *Micropterus salmoides* (LMB) in Idaho (Dillon 1991). A conclusion of that work indicated that water temperature was a key factor controlling LMB productivity. Additionally, several other studies describe the growth potential of LMB across their natural range (McCauley and Kilgour 1990; Beamesderfer and North 1995). These studies identify the maximum growth potential for LMB in the predominately coldwater lakes and reservoirs in Idaho. However, many other factors can contribute to the population structure and success of a LMB fishery. Most importantly are harvest, lake productivity, and interactions among fish species (i.e., competition and predation). Monitoring these variables is necessary to maintain or improve LMB fisheries in southeast Idaho. We evaluated the Largemouth Bass and potential prey species communities in five southeast Idaho reservoirs during 2013.

Reservoirs evaluated in 2013 are small (< 200 ha), shallow, and productive. Species composition, surface area and Largemouth Bass harvest rules vary by reservoir (Table 3). Largemouth Bass, Bluegill (BG) *Lepomis macrochirus* and potential prey species abundance were evaluated using shoreline electrofishing in 2013. Catch-per-unit-effort (CPUE, fish/hr) was used to compare the relative abundance of LMB among the different reservoirs. The CPUE data were collected using night-time shoreline electrofishing with boat-mounted equipment. All electrofishing was completed in June between 2100 and 0400 hours. Netting effort varied depending on catch rates. The first priority was to obtain a random sample of all species. In some waters, BG densities were too high to continually net that species and achieve the sample goal for LMB. In such cases, selective netting for LMB was implemented. Size selective netting periods for LMB were not included in CPUE or Proportional Stock Density (PSD) analysis. Fish were weighed to the nearest gram and measured for total length (mm).

Table 3. Species composition and Largemouth Bass harvest regulations for reservoirs included in the 2013 warmwater fishery evaluations.

| Water | Elevation (m) | Surface Area (ha) | Species Composition | Harvest Regulations |
|---|---|---|---|---|
| Twin Lakes | 1,452 | 180 | LMB[a], BG[b], CR[c], RBT[d] | 6 none under 12" |
| Condie | 1,500 | 47 | LMB, BG, YP[e] | 2 none under 20" |
| Glendale | 1,509 | 93 | LMB, BG, RBT, YP, CR | 2 none under 16" |
| Lamont | 1,485 | 37 | LMB, BG, YP, RBT,CR | 6 none under 12" |
| Johnson | 1,485 | 20 | LMB, BG, RBT, YP | 6 none under 12" |

[a] Largemouth Bass.
[b] Bluegill.
[c] Crappie.
[d] Rainbow Trout.
[e] Yellow Perch.

## Results and Discussion

Catch rates of warmwater species varied markedly among reservoirs. Bluegill were most abundant in Johnson Reservoir followed by Lamont, Twin Lakes and Condie reservoirs, respectively (Table 4). No Bluegill were observed in Glendale Reservoir. Largemouth Bass were most abundant in Johnson Reservoir and the least abundant in Condie Reservoir (Table 4). During the fall of 2012, Condie Reservoir was extremely low due to irrigation withdrawal. At that time, a large group of American White Pelicans *Pelecanus erythrorhynchos* were observed foraging heavily there. We think the low abundance of both LMB and BG observed in 2013 can be attributed to the pelican predation that occurred the previous year. In the case of LMB, most of the juvenile cohorts were lost during this predation event (Figure 3).

Table 4. Electrofishing catch-per-unit-effort (fish/hr)in five southeast Idaho reservoirs in 2013. Proportional Stock Density values for Largemouth Bass (LMB) and Bluegill (BG) are shown in parenthesis.

| Species | Twin Lakes | Condie | Glendale | Johnson | Lamont |
|---|---|---|---|---|---|
| LMB | 54 (45) | 52 (88) | 71 (60) | 171 (17) | 71 (11) |
| BG | 83 (67) | 6 (N/A) | None | 757 (40) | 223 (41) |

Proportional Stock Density values for the five reservoirs we sampled are highly variable (Table 5). In 2013, PSD values were highest for Glendale and Condie reservoirs, which have more restrictive bass harvest rules. Protective harvest regulations may moderate the fluctuations in PSDs, but do not appear to guarantee quality fishing. For example, Condie Reservoir is managed using the trophy bass rule of no harvest of LMB under 508 mm. Despite the conservative harvest rule, the PSD in this reservoir fluctuates widely among survey years (Table 5). Generally, the lowest LMB PSDs are observed in reservoirs that are managed under general angling regulations (6 bass, none under 305 mm), suggesting that once LMB are recruited to legal size, they are harvested by anglers (Figure 3). Despite the general bass harvest rules, Twin Lakes appears to provide moderate PSD for Largemouth Bass (Table 5). Based on recent conversations with anglers, Twin Lakes likely attracts more catch-and-release anglers than Johnson and Lamont Reservoirs. This may explain why LMB PSDs in Twin Lakes are usually higher than in other general regulation waters.

Similar to LMB, BG PSDs were also variable in the five reservoirs surveyed. Twin Lakes had the highest PSD followed by Lamont, Johnson, and Condie reservoirs (Table 5). Bluegill are present in Glendale Reservoir, however, we were unable to sample any during the survey. We suspect that during the survey, BG were occupying deeper portions of the reservoir and were therefore not susceptible to shoreline electrofishing methodology.

Table 5. Proportional Stock Density (PSD) for Largemouth Bass in five southeast Idaho reservoirs by year. Values in parentheses were based on data obtained from Largemouth Bass fishing tournaments. Glendale and Lamont were not sampled in 2011.

| Year | Condie | Johnson | Glendale | Lamont | Twin Lakes |
|---|---|---|---|---|---|
| 1986 | | | | 13 | |
| 1987 | | | | | |
| 1988 | 30 | | 9 | | 25 |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | | | | 3 | |
| 1993 | 21 | | 6 | 1 | |
| 1994 | 58 | | | | |
| 1995 | (76) | | (86) | 1 | |
| 1996 | | | | | |
| 1997 | (73) | | (94) | | |
| 1998 | | | 83 | | |
| 1999 | 43 | | (75) | | 0 |
| 2000 | | | (97) | | |
| 2001 | | | | | |
| 2002 | 97 | | 56 | 8 | 0 |
| 2003 | 14 | | | | |
| 2004 | | | | | |
| 2005 | | | (100) | | |
| 2006 | 20 | | 56 | 13 | 48 |
| 2008 | 90 | | 23 | | |
| 2010 | 36 | 12 | 84 | 8 | |
| 2011 | 57 | 26 | | | 17 |
| 2013 | 88 | 17 | 60 | 11 | 45 |

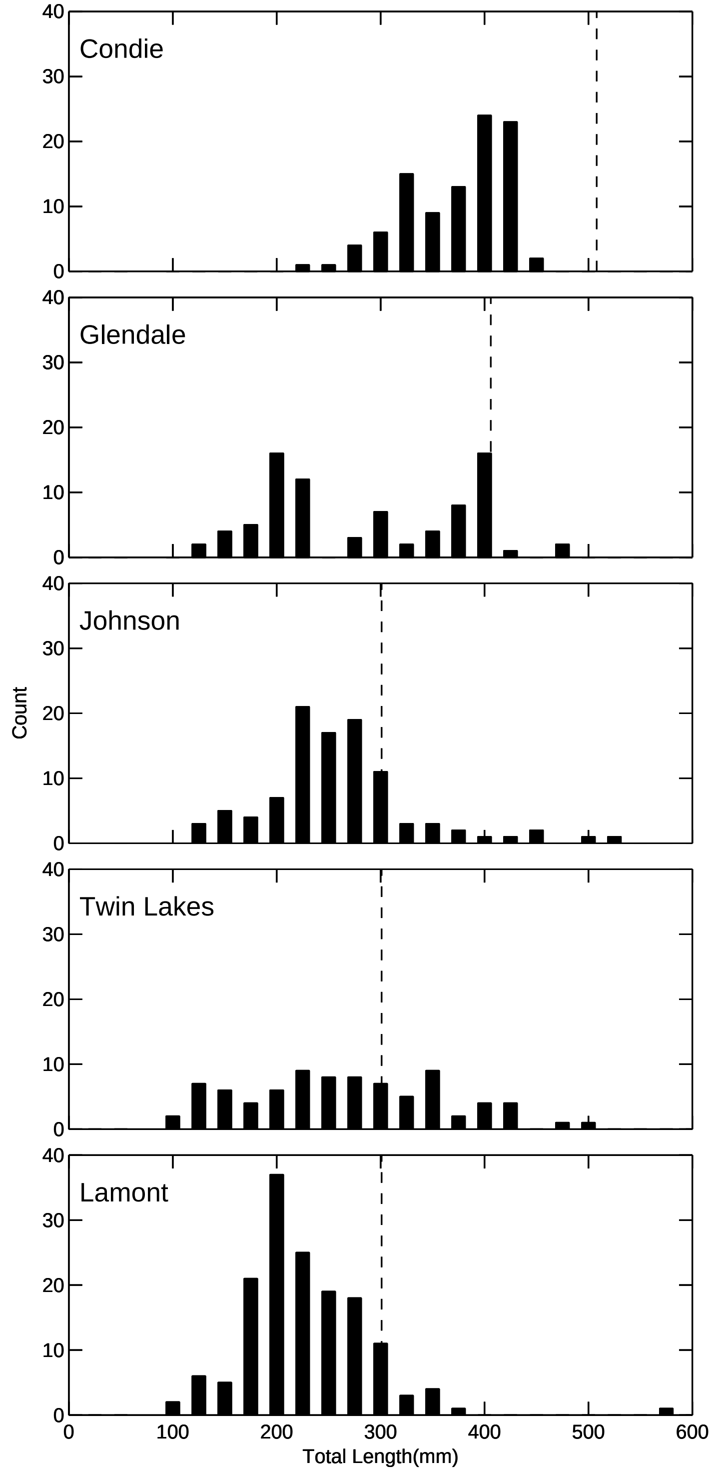


Figure 3. Largemouth Bass length frequency distributions from five southeast Idaho reservoirs in 2013. Vertical dashed lines represent the minimum total length when bass can be legally harvested.

## Double-crested Cormorant Predation in Franklin County Waters

### Introduction and Methods

Foster, Glendale and Treasureton Reservoirs are popular Rainbow Trout *Oncorhynchus mykiss* (RBT) fisheries located in Franklin County near Preston, Idaho. Foster and Glendale Reservoirs are managed under general fishing regulations (6 trout/day, no length or bait restrictions) while Treasureton Reservoir is managed under trophy trout regulations (2 trout, none under 20 inches, no bait).

Over the past decade, Double-crested Cormorant *Phalakros auritus sp.* (DCC) use of these reservoirs has increased (Brimmer et al. 2012). Concerns have arisen regarding the predation impacts these birds may be having on the RBT fisheries found there. Therefore, the objective of this project was to evaluate the predation impacts by DCC on RBT in Foster, Glendale and Treasureton Reservoirs.

During 2013, we PIT (Passive Integrated Transponder) tagged a portion RBT stocked in Foster, Glendale and Treasureton Reservoirs. We used Half Duplex 23 mm tags purchased from ORFID (www.oregonrfid.com). In May, we randomly selected RBT from Grace and American Falls fish hatcheries that were to be stocked into the three reservoirs; PIT tagged them and released them back into the raceway they came from. Tagged fish were stocked along with the general release groups in Foster Reservoir on 5-May-13, Glendale Reservoir on 13-Jun-13 and Treasureton Reservoir on 3-Jun-13.

We attempted to recover PIT tags at two locations during the summer and fall of 2013. The first area where we recovered PIT tags was a small island located in the middle of Foster Reservoir. The second was a DCC nesting colony located on the Bear River near Smithfield, Utah. Double-crested Cormorants found at Foster Reservoir did not nest there but spent time loafing/roosting in the trees on the island. See Appendix A. for tag recovery methods.

### Results and Discussion

Overall, we recovered 179 out of 991 PIT tags deployed at the three reservoirs in 2013. Tagged RBT released at Foster Reservoir had the highest recovery rate of 34% followed by Treasureton and Glendale at 20% and 5%, respectively (Table 6). Foster Reservoir likely had the highest recovery rate of the three reservoirs because the DCC loafing/roosting area is located there. Both Glendale and Treasureton are some distance away from Foster so a fraction of the tags consumed by DCC at Glendale and Treasureton reservoirs were probably deposited at those reservoirs or were excreted during the flight back to Foster Reservoir. Only two PIT tags were recovered from the rookery at Smithfield, Utah, which may be due to its distance from the Franklin County reservoirs or predation impacts may be lower. Since the number of recoveries was low, we combined them with Foster Reservoir recoveries.

Table 6. Total Rainbow Trout stocked and tagged with Passive Integrated Transponder (PIT) tags at Foster, Glendale and Treasureton reservoirs in 2013. Passive Integrated Transponder tags recovered from Foster Reservoir and a Double-crested Cormorant rookery near Smithfield, Utah are also included.

| | | | PIT Tag Recovery Location | | | |
|---|---|---|---|---|---|---|
| Release Location | Number of PIT Tags Released | Total RBT Released | Foster | Smithfield | Tot. Number of PIT Tags Recovered | Recovery Rate (%) |
| Foster | 293 | 3,915 | 98 | 2 | 100 | 34 |
| Glendale | 399 | 6,590 | 20 | 0 | 20 | 5 |
| Treasureton | 299 | 12,296 | 59 | 0 | 59 | 20 |
| TOTALS | 991 | 22,801 | 177 | 2 | 179 | 18 |

Our findings suggest DCC predation on the RBT fisheries in Foster, Glendale and Treasureton reservoirs presents a significant economic loss to anglers. We estimated the hatchery production costs lost to DCC predation by applying the PIT tag recovery rates to the total number of RBT released at each location. Foster Reservoir lost at a minimum 1,331 RBT to DCC predation which equates to a production cost of about $2,289 (Each RBT valued at $1.72 Table 7). Furthermore, because of DCC predation impacts, there were fewer RBT available for harvest, which reduced angler opportunity and fishing quality. Overall, we estimated that DCC consumed at least 4,120 RBT at a production cost of about $7,086. See Table 7 for specific costs associated with Glendale and Treasureton Reservoirs.

Table 7. Total Rainbow Trout (RBT) stocked and estimated consumption by Double-crested Cormorants (DCC) at three Franklin County Reservoirs, Idaho, in 2013. Hatchery production costs associated with predation losses (based on cost of $1.72/fish) are also reported.

| Water Body | RBT Stocked | PIT Tag Recovery Rate (%) | RBT Consumed by DCC | Production Cost ($) |
|---|---|---|---|---|
| Foster | 3,915 | 34 | 1,331 | 2,289 |
| Glendale | 6,590 | 5 | 330 | 568 |
| Treasureton | 12,296 | 20 | 2,459 | 4,229 |
| TOTALS | 22,801 | | 4,120 | 7,086 |

While the results of this study indicate DCC predation on RBT in three Franklin County Reservoirs is significant, only a portion of total predation has been presented here. For example, we observed a tag recovery rate of 34% (Foster) which was derived by dividing the number of PIT tag recoveries by the total number of PIT tags released or in the case of Foster Reservoir, 100/293 (34%; Table 6). To expand this percentage to the entire release group, we multiplied the total number of fish stocked (3,915) by 0.34. These equations only represent the PIT tags that were recovered. Our estimates do not account for PIT tags deposited by DCC outside our search area. Therefore, the total number of RBT consumed by DCC and the cost associated with that loss is likely much higher than reported here.

The ultimate goal of this project is to estimate total predation impacts of DCC on Franklin County RBT fisheries and to attribute a cost to those losses. To that end, we will be developing a correction factor so we can estimate total consumption of RBT by DCC.

## Chesterfield Reservoir

### Introduction and Methods

Chesterfield Reservoir is a popular trout fishery in southeast Idaho. During the 1990s, the fishery was managed under general harvest rules that included a six trout daily bag limit with no size or bait restrictions. Those regulations maximized yield from the reservoir. In 1994, anglers fished an estimated 158,000 hours and harvested over 70,000 Rainbow Trout *Oncorhynchus mykiss* (RBT). Despite the popularity of the fishery, anglers began requesting more restrictive harvest regulations to allow trout to grow to quality size. In response to angler requests and creel analysis that showed harvest would be significantly reduced under more conservative bag limits, the trout limit was reduced from 6 to 3 fish per day in 1998. The bag limit was reduced a second time to 2 trout/day in 2002.

Over the past decade, American White Pelican *Pelecanus erythrorhynchos* (AWPE) and Double-crested Cormorant *Phalakros auritus* (DCC) use of Chesterfield Reservoir has increased (Brimmer et al. 2011). Concerns have arisen regarding the predation impacts these birds may be having on the RBT fishery in Chesterfield Reservoir. The objective of this study was to estimate Rainbow Trout total predation by AWPE in Chesterfield Reservoir.

During 2013, we PIT (Passive Integrated Transponder) tagged RBT stocked in Chesterfield Reservoir. We used Half Duplex 23 mm tags purchased from ORFID (www.oregonrfid.com). In May, we randomly selected RBT from a larger group of fish from Hagerman State Fish Hatchery to be stocked into the reservoir; PIT-tagged them and released them back into the raceway they came from. These fish were stocked in Chesterfield Reservoir on 07-May. In addition to the tagged group of stocked hatchery RBT mentioned above, we also PIT tagged and fed RBT to AWPE that were actively foraging on Chesterfield Reservoir to estimate predation losses to pelicans and tag recovery rates. Feeding events occurred in May and June. See Appendix A. for feeding and predation rate estimate details. We attempted to recover PIT tags at three locations during the summer and fall of 2013. The first area we recovered PIT tags from was a small island located at the north end of Chesterfield Reservoir. American White Pelicans and DCC loafed on this island while at the reservoir. The second and third locations were from Gull and Willow Islands located on Blackfoot Reservoir. See Appendix A. for tag recovery methods.

### Results and Discussion

Overall, we recovered 165 out of 465 PIT tags deployed at Chesterfield Reservoir in 2013. Of the 80 PIT-tagged RBT fed to AWPE, we recovered 13; 5 (38%) from Gull Island, 8 (62%) from Willow Island and none from Chesterfield Reservoir. The tag recovery rate for RBT fed to AWPE was relatively low at 16%. Tag recovery rates of stocked RBT differed from tagged RBT fed to AWPE. If AWPE are the primary predator on Chesterfield RBT, the tag recovery rate of stocked fish should have been similar to fed fish. . Of the 385 tags included in the 28,576 RBT stocked in May, 51 (34%) were recovered from Chesterfield Reservoir, 99 (65%) from Gull Island and only 2 (1%) from Willow Island (only pelicans nest there) on Blackfoot Reservoir. Of the 99 tagged at large RBT recovered from Gull Island, 29 where extracted directly from DCC nests. Furthermore, the majority of the remaining 70 tags were recovered within the DCC nesting colony. These data suggest that while pelicans may consume a proportion of RBT,DCC are predating Chesterfield RBT at a much high rate.

As mentioned above, we planned to estimate total predation by AWPE in 2013. However due to significant predation impacts by DCC (and no DCC were fed PIT tagged fish), we were unable to do so. Therefore, we only report a combined tag recovery rate for AWPE and DCC. In 2013, the combined tag recovery rate of 39% was similar to what was observed in 2011 and 2012 (Brimmer et al. 2013). When the raw tag recovery rate was applied to the total number of at large RBT released at Chesterfield, we estimated that at least 11,145 fish were lost to avian predation. Furthermore, the absolute minimum cost associated with this loss is estimated to be about $19,169 (each fish is valued at $1.72. To reduce these losses, we plan to stock RBT in the spring of 2014; just after ice out but before the piscivorous birds arrive at the reservoir. We think this approach will give the fish a chance to acclimate to their new environment which in turn may reduce their vulnerability to predation.

## MANAGEMENT ROCOMMENDATIONS

1. Evaluate the fishery improvement efforts completed at Johnson Reservoir.
2. Continue the avian predation studies currently underway.
3. Devise a way to estimate total predation by Double-Crested Cormorants that can be applied to area waters.

## RIVERS AND STREAMS INVESTIGATIONS AND SURVEYS


## ABSTRACT

We surveyed the Blackfoot and Bear river systems using electrofishing and trapping in 2013. Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT) escapement from Blackfoot Reservoir to the Blackfoot River (1,843) in 2013 was the highest observed since 2001 (4,747). We attribute this large increase in run size to our extensive efforts to haze and lethally reduce American White Pelicans *Pelecanus erythrorhynchos* (AWPE) foraging on the river during the latter part of the YCT run. While pelicans were present on the river, few trout were trapped on a daily basis. Once pelican occupancy declined, trout movement increased substantially. This late movement of YCT represented half of all the fish caught. We speculate that pelicans foraging on the river act as a deterrent to YCT migration. Therefore, we recommend the hazing/take program be initiated as soon as YCT start arriving at the trap and continued aggressively until the end of the migration run. A total of 65 YCT were sampled on the Blackfoot River Wildlife Management Area (BRWMA) during the mark and recapture electrofishing surveys. The number of YCT caught in 2013 was the lowest on record. We think AWPE predation on BRWMA YCT was a contributing factor to the low number of YCT encountered in 2013.

As part of our ongoing efforts to monitor Bonneville Cutthroat Trout *O. c. utah* (BCT), we sampled eight streams: five sites within the Thatcher Management Unit, seven within the Riverdale Management Unit and two within the Malad Management Unit. Overall, mean BCT density was 8.1 BCT/100 $m^2$ (±3.0; range 0.8 – 27.2). The highest BCT density was observed in Third Creek (27.2 BCT/100 $m^2$) and the lowest in Beaver Creek (0.8 BCT/100$m^2$). The percent composition of BCT in relationship to other salmonids sampled varied between streams. Whiskey Creek had the lowest composition of BCT (43%) while Stockton, Hoopes and Third creeks had the highest at 100%.

# Yellowstone Cutthroat Trout Monitoring in the Blackfoot River System

## Introduction and Methods

There are two long-term monitoring programs in place for Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT) in the upper Blackfoot River. These include adult spawning counts and population estimates within the Blackfoot River Wildlife Management Area (BRWMA) located about 51 km above the reservoir. The spawning counts have been completed every year since 2001, while population surveys are completed less frequently.

An electric fish migration barrier was installed in the Blackfoot River in 2003 to collect migrating YCT entering the Blackfoot River from Blackfoot Reservoir. The barrier includes a trap box designed using Smith Root Inc. specification. The barrier components include four flush mounted electrodes embedded in Insulcrete, four BP-X.X.-POW pulsators, and a computer control and monitoring system. The computer system can be operated remotely, records electrode outputs, and has an alarm system that triggers during power outages. Detailed descriptions of these components and their function can be obtained at www.smith-root.com.

The electric barrier was operated from 2-May-13 to 23-June-13. Prior to observing YCT at the trap, field crews checked the live box several times a week. Once fish began entering the trap, it was checked at least once a day. Data collected from trapped fish included species, total length (mm) and weight (g). Yellowstone Cutthroat Trout were visually examined for bird scars beginning in 2004. Scar rates were associated with increases in American White Pelicans (AWPE) feeding in the Blackfoot River downriver of the trap. All salmonids handled at the trap were injected with a 32 mm Half Duplex Passive Integrated Transponder (PIT) tag purchased from Oregon RFID (oregonrfid.com). These fish were tagged so they could be included in a related pelican predation study.

In 1994, the Idaho Department of Fish and Game (IDFG), with assistance from the Conservation Fund, purchased the 700-ha ranch and began managing the property as the BRWMA. The BRWMA straddles the upper Blackfoot River, with an upper boundary at the confluence of Lanes, Diamond, and Spring creeks and a lower boundary at the head of a canyon commonly known as the upper narrows. Approximately 9 km of river meander through the property along with 1.6 km of Angus Creek, which is an historical YCT spawning and rearing stream. Since purchasing the BRWMA, IDFG has completed periodic population estimates to monitor YCT abundance.

In 2013, we attempted to estimate YCT abundance within 5.2 km of the BRWMA reach of the Blackfoot River with a mark-recapture study. We used boat mounted electrofishing gear to collect YCT from the entire reach. However, during the initial marking run, too few fish were captured to allow for a valid population estimate to be completed. The YCT captured during the marking run were injected (marked) with a 23 mm PIT tag (oregonrfid.com) and were measured for total length (mm) and weighed to the nearest gram. Fish were marked on 23-Jun but no recapture run was attempted.

Non-lethal hazing and lethal take of AWPE was utilized in 2013 in an attempt to reduce predation impacts on migrating YCT. From May to July, hazers patrolled the river from the confluence with the reservoir to the confluence of Lanes and Diamond Creeks on foot or via ATV. When groups of pelicans were observed on the river, hazers launched explosive pyrotechnics towards the group of birds to scare them off the river. Hazing crews also enumerated AWPE encountered each day. In addition to non-lethal hazing, lethal take was also used to discourage pelican use of the river. Lethal take occurred in concert with non-lethal hazing.

**Results and Discussion**

In 2013, a total of 1,843 adult YCT were collected at the migration trap. Of these, 1,388 were females and 452 were males. No sex determination could be made on the remaining 3 fish. Captured females and males had a mean total length of 479 and 510 mm, respectively. The bird scarring rate observed in 2013 was 34%, the second highest observed since 2006. Scarring rates have varied from no visible scars on fish collected in 2002 to a high of 70% scarred in 2004. Scarring rates may be related to the pelican predation rate, but no information is available to determine the relationship. Variation in scarring rates is likely impacted by the overall number of AWPE feeding on the river below the migration trap, water levels and clarity, and hazing efforts to reduce predation impacts. Adult YCT escapement and bird scar trends are shown in Table 8.

A total of 65 YCT were sampled on the BRWMA during the mark and recapture electrofishing surveys (Table 9). The number of YCT caught in 2013 was the lowest on record. We think AWPE predation on BRWMA YCT was a contributing factor to the low number of YCT encountered in 2013 (Appendix A).

In past surveys of the BRWMA reach, juveniles (< 300 mm) dominated the catch. Thurow (1981) reported that about 80% of the fish caught during population surveys were less than 300 mm total length. Results from 2010, 2011, 2012 and 2013 surveys show similar ratios of juvenile cohorts (Figure 4).

Table 8. Yellowstone Cutthroat Trout escapement estimates and American White Pelican counts for the Blackfoot River from 20012013. No escapement estimates are available in 2011 due to extremely high river discharge.

| Year | Weir Type | YCT Count | Mean Length(mm) | % Bird Scars | Mean May River Discharge (cfs) | Adult Pelican Count |
|---|---|---|---|---|---|---|
| 2001 | Floating | 4,747 | 486 | No data | 74 | No data |
| 2002 | Floating | 902 | 494 | 0 | 132 | 1,352 |
| 2003 | Electric | 427 | 495 | No data | 151 | 1,674 |
| 2004 | Electric | 125 | 478 | 70 | 127 | 1,748 |
| 2005 | Electric | 16 | Na | 6 | 388 | 2,800 |
| 2006 | Electric | 19 | Na | 38 | 453 | 2,548 |
| 2007 | Electric | 98 | 445 | 15 | 115 | 3,416 |
| 2008 | Electric | 548 | 485 | 10 | 409 | 2,390 |
| 2009 | Electric | 865 | 484 | 14 | 568 | 3,174 |
| 2010 | Electric | 938 | 468 | 12 | 248 | 1,734 |
| 2011 | Electric | Na | Na | Na | 936 | 724 |
| 2012 | Electric | 530 | 483 | 37 | 200 | 3,034 |
| 2013 | Electric | 1,843 | 486 | 34 | 176 | 1,996 |

Table 9. Yellowstone Cutthroat Trout abundance estimates collected from the Blackfoot River Wildlife Management Area of the Blackfoot River, Idaho.

| Year | Fish Marked | Fish Captured | Fish Recaptured | % Recaptured | Pop. Estimate | Pop. Estimate SD |
|---|---|---|---|---|---|---|
| 2005 | 266 | 202 | 20 | 7.5 | 3,664 | 569.1 |
| 2006 | 339 | 450 | 57 | 16.8 | 3,534 | 352.3 |
| 2008 | 223 | 186 | 28 | 12.6 | 2,504 | 336.5 |
| 2009 | 279 | 319 | 44 | 15.8 | 2,567 | 286.5 |
| 2010 | 317 | 272 | 11 | 3.5 | 12,944 | 4,131.2 |
| 2011 | 318 | 147 | 16 | 5.0 | 3,222 | 411.3 |
| 2012 | 137 | 99 | 12 | 12.1 | 1,672 | 421.7 |
| 2013 | 65 | N/A | N/A | N/A | N/A | N/A |
| Mean[a] | 260 | 234 | 30 | 11.6 | 2,861 | 396.2 |

[a]Excludes 2010 and 2013.

Hazing and lethal take began on 6 May 2013 and continued through 28 June 2013. American White Pelicans were hazed 1-2 times daily from the Blackfoot River Road Bridge (Hwy 34) downstream to the river's confluence with the reservoir (about 2.0 km). Efforts to haze AWPE on the upper River on or near the BRWMA occurred from 13 June through 28 June (the BRWMA is about 30 miles above the reservoir.

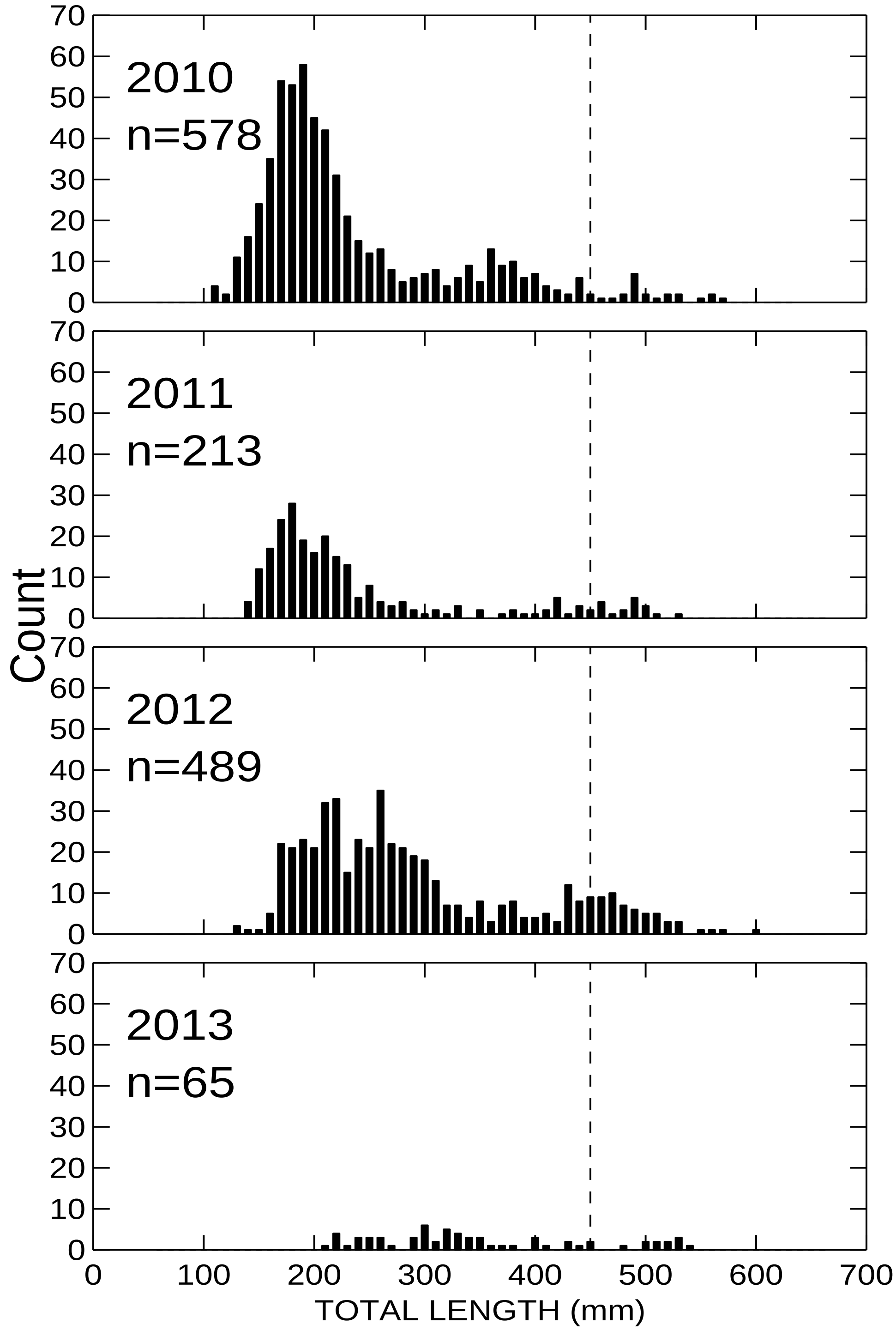


Figure 4. Length frequency distributions of Yellowstone Cutthroat Trout caught from the Blackfoot River Wildlife Management Area of the Blackfoot River, Idaho. The majority of fish located to the right of the vertical dashed lines are likely post-spawn adfluvial fish that may return to Blackfoot Reservoir.

Typically, the majority of adult YCT are captured at the trap during May. During 2008, 2009 and 2012, over 90% of the total number of trout captured occurred in May. However, in 2013 the total catch was split evenly between May and June. We observed a similar event in 2010. In 2010, we experienced a long cool protracted spring which delayed run off and the return of adult YCT for about two to three weeks. This may explain the unusually high number of fish captured in June that year (Brimmer et al. 2011).The spring of 2013 was near normal in all respects so unusual weather conditions do not explain why half of the returning adults were captured in June. Presence of foraging AWPE in the river below the trap might explain the alteration in the normal migration timing.

During May, AWPE use (hourly counts of AWPE obtained from trail cameras) of the Blackfoot River below the trap was high and averaged over 200 birds per day (Figure 5). During this time, pelicans were hazed on a daily basis, but lethal take was low (1 to 2 birds per day). Yellowstone Cutthroat Trout average daily catch at the trap was also relatively low during May. However, during the first few days of June we increased lethal take of AWPE from 1 or 2 birds per day to up to 6 birds per day. When lethal take reached 4-6 birds per day, AWPE use of the river declined dramatically (Figure 5). Once pelican use declined, YCT moved up river in large numbers over a short period of time (Figure 5). It appears that high concentrations of foraging AWPE can effectively prevent the migration of YCT. We recommend that lethal take of AWPE be pursued more aggressively in the future, particularly from the first week of May until June, or whenever the YCT migration has ended.

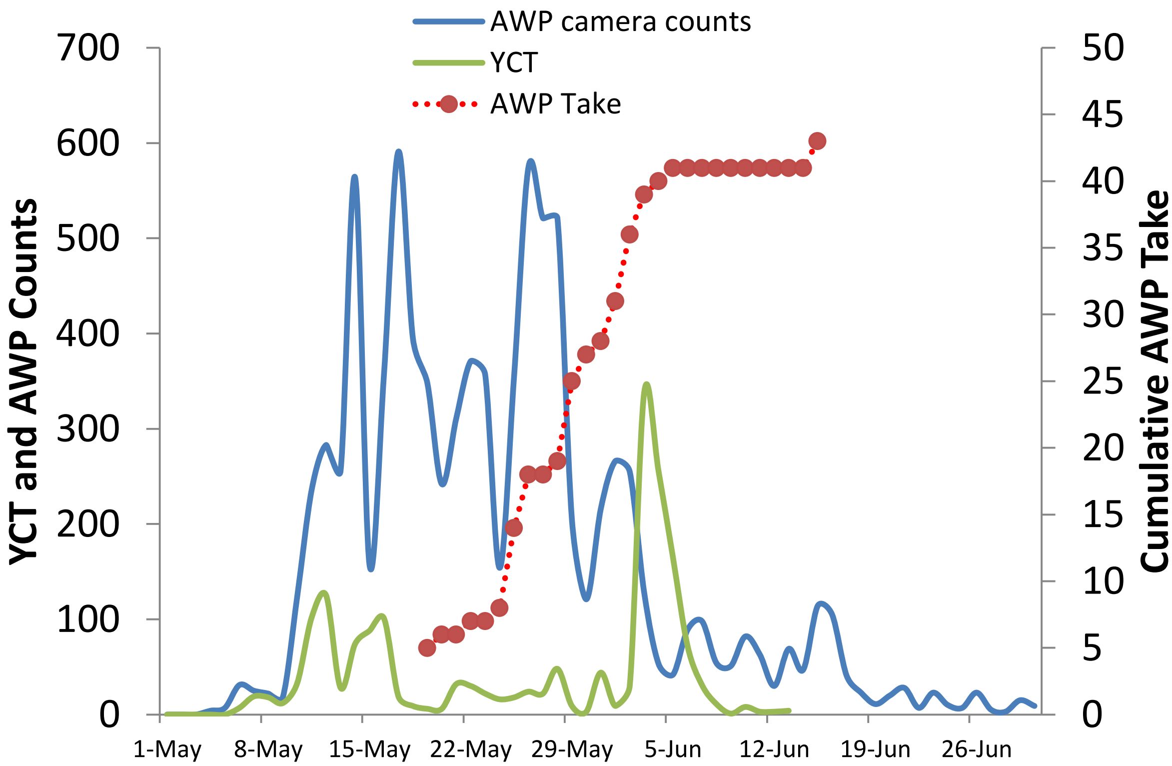


Figure 5. Counts of American White Pelicans and Yellowstone Cutthroat Trout encountered on the upper Blackfoot River during May and June of 2013. Cumulative lethal take of American White Pelicans is also included.

## Bonneville Cutthroat Trout Monitoring Program

### Introduction and Methods

Bonneville Cutthroat Trout *Oncorhynchus clarkii utah* (BCT) are one of three native cutthroat trout sub-species in Idaho. The distribution of BCT is limited to the Bear River drainage in Southeastern Idaho. In the early 1980s, distribution and abundance data for this native trout were deficient. A long-term monitoring program was initiated for three tributary streams of the Thomas Fork Bear River (Preuss, Giraffe, and Dry Creeks) to better understand BCT population trends and the influence of natural and anthropogenic processes on BCT populations.. Initial monitoring plans intended for these streams to be sampled every other year. In 2006, as part of the BCT management plan (Teuscher and Capurso 2007), additional streams were added to the BCT monitoring program to include a broader representation of BCT population trends from across their historical range in Idaho. These additional monitoring streams included Eightmile, Bailey, Georgetown, Beaver, Whiskey, Montpelier, Maple, Cottonwood, Snow slide, First, Second, and Third creeks, and the Cub River. In 2010, IDFG personnel determined that the BCT monitoring efforts would be improvedby dropping some sites and streams initiated in 2006, while adding other streams throughout the four BCT management units in the Bear River drainage (Figure 6). Currently, the monitoring program consists of three streams and eight sites in the Pegram Management Unit (PMU), six streams and 14 sites in the Nounan Management Unit (NMU), four streams and nine sites in the Thatcher Management Unit (TMU), four streams and eight sites in the Riverdale Management Unit (RMU), and three streams and six sites in the Malad Management Unit (MMU; Table 10). We will sample half of these streams annually. In addition, the monitoring program includes two segments of the main-stem Bear River in each of the management units. Main-stem Bear River segments in each management unit will be sampled every four years.

There are a number of variables that may influence BCT population trends which include annual precipitation, water temperature, irrigation, grazing, etc. (Teuscher and Capurso 2007). Given the sensitive status of BCT and recent petitions to list it under the Endangered Species Act, it is important to identify and correlate variation in BCT densities that appear to be associated with these and other suspected variables. Therefore in 2011, we collected a suite of habitat variables to begin monitoring potential changes in habitat and stream channel condition. The descriptions of these habitat variables and collection methods are listed in Table 11. In the future, habitat data will be correlated to variation in BCT abundance. Analysis of habitat variables require many years of data collection, therefore, no statistical analysis will be reported until sufficient data is collected.

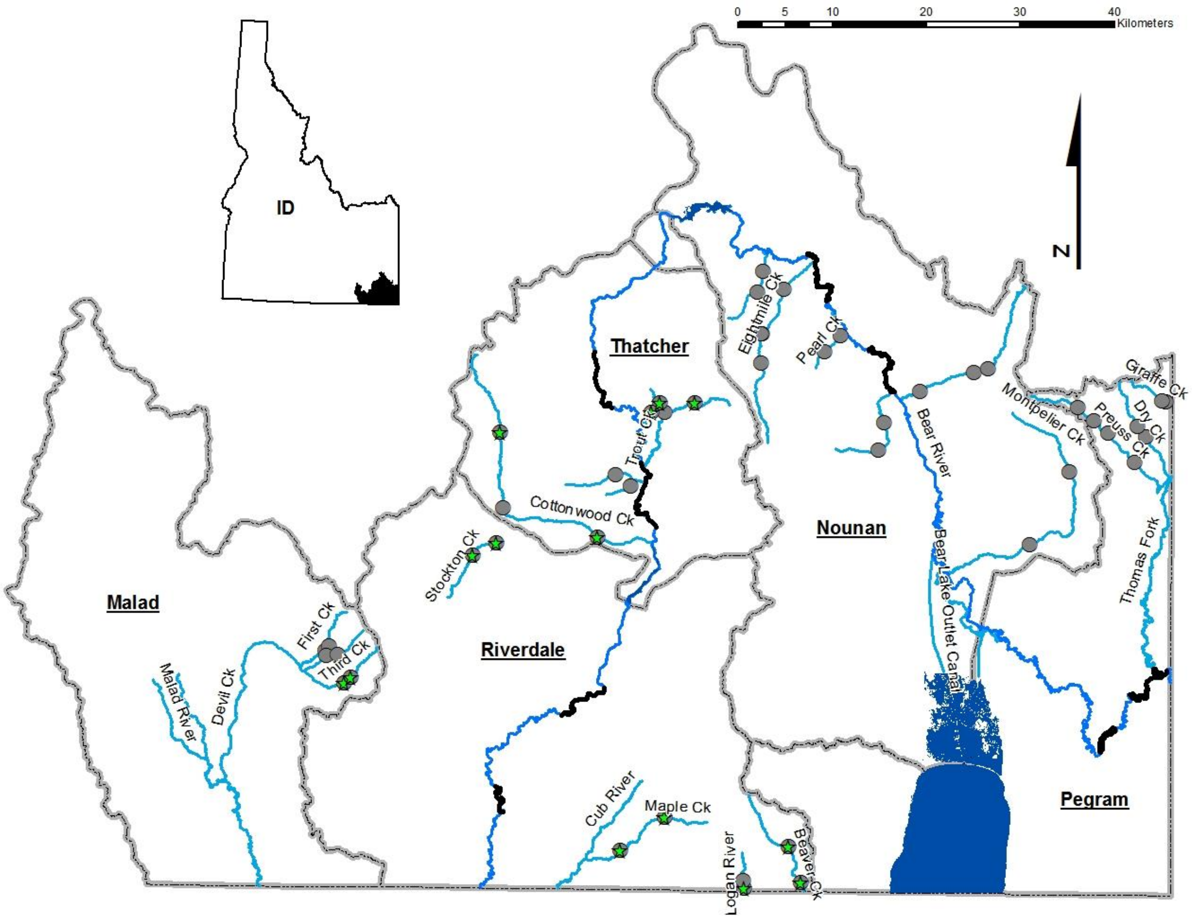


Figure 6. Map of the Bear River watershed in Idaho, including the six Bonneville Cutthroat Trout management units. The gray circles represent monitoring sites and gray circles with a green star represent sites that were sampled in 2013. The black line segments on the main-stem Bear River represent monitoring reaches. No main-stem Bear River sites were sampled in 2013.

We sampled BCT from at least two sites on each stream using multiple pass removal techniques with backpack electro-fishing equipment. At each site, a segment of stream (approximately 100 m) was sampled, which included block nets at the downstream and upstream boundaries. The area ($m^2$) sampled was calculated using length (m) and average width (m). We calculated a population estimate using Microfish 3.0 software (Microfish Software, Durham, NC, USA). BCT percent composition was calculated by dividing the number of BCT by the total number of all salmonids sampled. Mean BCT density (fish/$m^2$) and percent composition for an entire stream were calculated by averaging the mean values from each site within a stream. Relative weights ($W_r$) were calculated for individual fish using the equation $Log_{10}W_s = -5.189 + 3.099\ log_{10}TL$ (Kruse and Hubert 1997). Mean $W_r$ for each stream was calculated as an average across all individual relative weight values.

Table 10. Number of sampling sites, sampled length and percent sampled for 20 monitoring streams within the five BCT management units.

| Management Unit | Stream | Sites | Stream Sampled (km) | Stream Length (km) | % Sampled |
|---|---|---|---|---|---|
| Pegram | Dry Ck. | 2 | 0.2 | 13.4 | 1.5 |
| | Giraffe Ck. | 2 | 0.2 | 5.7 | 3.5 |
| | Preuss Ck. | 4 | 0.4 | 22.0 | 1.8 |
| | Bear River | 2 | 17.2 | 61.2 | 28.1 |
| Nounan | Bailey Ck. | 2 | 0.2 | 9.9 | 2.0 |
| | Eightmile Ck. | 3 | 0.3 | 23.6 | 1.3 |
| | Georgetown Ck. | 3 | 0.3 | 21.8 | 1.4 |
| | Montpelier Ck. | 2 | 0.2 | 36.0 | 0.6 |
| | Pearl Ck. | 2 | 0.2 | 5.3 | 3.8 |
| | Stauffer Ck. | 2 | 0.2 | 14.5 | 1.4 |
| | Bear River | 2 | 18.8 | 94.5 | 19.9 |
| Thatcher | Cottonwood Ck. | 3 | 0.3 | 37.4 | 0.8 |
| | Hoopes Ck. | 2 | 0.2 | 13.5 | 1.5 |
| | Trout Ck. | 2 | 0.2 | 18.3 | 1.1 |
| | Whiskey Ck. | 2 | 0.2 | 5.1 | 3.9 |
| | Bear River | 2 | 18.0 | 37.8 | 47.6 |
| Riverdale | Beaver Ck. | 2 | 0.2 | 13.7 | 1.5 |
| | Logan R. | 2 | 0.2 | 4.7 | 4.3 |
| | Maple Ck. | 3 | 0.3 | 16.1 | 1.9 |
| | Stockton Ck. | 2 | 0.2 | 9.8 | 2.0 |
| | Bear River | 2 | 13.6 | 50.2 | 27.1 |
| Malad | First Ck. | 2 | 0.2 | 9.0 | 2.2 |
| | Second Ck. | 2 | 0.2 | 8.4 | 2.4 |
| | Third Ck. | 2 | 0.2 | 11.2 | 1.8 |

Table 11. List of habitat variables, units of measurement and collection methods for habitat characteristics used to explain variation in BCT abundance estimates.

| Habitat Variable | Unit of Measurement | Collection Methods |
|---|---|---|
| Water Temperature | Celsius | Measured at beginning of survey with handheld thermometer to the nearest ± 0.5 (°C). |
| Conductivity | µs/cm | Measured at beginning of survey with conductivity meter to the nearest ± 0.1 (µs/cm). |
| Discharge | $ft^3$/sec | Measured stream discharge with Rickly discharge meter in a uniform stream segment, using methods proposed by Harrelson et al. (1994) |
| Gradient | Percent | Gradient was calculated using aerial imagery by calculating the difference in water elevation from an upstream location to a downstream location that was greater than 50 meters apart. |
| Stream Width | Meters | Measure the wetted width (± 0.1 m) of the stream at ten (10) equally spaced transects within the survey reach and then calculate the mean reach width. |
| Stream Depth | Centimeters | At ten (10) equally spaced transects, measure and sum the depth (± 1 cm) of the stream at ¼, ½, and ¾ distance across the channel and divide by four. Use these values to calculate the mean reach depth. |
| Width/Depth Ratio | Meters | Convert the mean reach depth into meters. Divide the mean reach width by the mean reach depth. |
| Percent Stable Banks | Percent | At the ten (10) equally spaced transects, determine and circle if the bank on the left and right are stable using the following definition. Streambank is stable if they DO NOT show indications of alteration such as breakdown, erosion, tension cracking, shearing, or slumping (Burton 1991). |
| Total Cover | Percent | Followed instructions from the streambank cover form in Bain and Stevenson (1999). |
| Canopy | Percent | Used a spherical densiometer and followed the methods of Platts (1987). |

**Results and Discussion**

In 2013, eight streams were sampled which included five sites within the TMU, seven within the RMU and two within the MMU (Figure 6). Overall, mean BCT density was 8.1 BCT/100 $m^2$ (± 3.0 95% CI); range 0.8 – 27.2). The highest BCT density was observed in Third Creek (27.2 BCT/100 $m^2$) and the lowest in Beaver Creek (0.8 BCT/100$m^2$; Table 12). The percent composition of BCT relative to other salmonids sampled varied between streams. Whiskey Creek had the lowest composition of BCT (43%), while several streams had 100% BCT composition (Table 12). The two sites on Hoopes Creek and the lower middle site on the Logan River were not sampled because water temperatures were greater than 20° Celsius. The middle upper site on Trout Creek was also not sampled because there was a fish kill in this reach.

Some streams in 2013 showed an increase in BCT densities compared to those estimated in 2011. These streams were Beaver Creek, Trout Creek, Whiskey Creek and Third Creek (Table 12). The increase in BCT densities in Trout and Whiskey Creek are probably related to stocking hatchery BCT in these reaches.

Most of the streams sampled this year exhibited a decrease in BCT densities compared to estimates in 2011. For instance, in the Logan River we only sampled the lowest site and the BCT density was 4.8/100$m^2$, whereas in 2011 BCT density at this same site was 11.5/100$m^2$ (Table 12). This is a considerable decrease in a two year period. These decreases could be related to the poor water conditions in 2012 and 2013, but future habitat analysis may be able to better explain annual variation in BCT densities.

## MANAGEMENT RECOMMENDATIONS

1. Continue American White Pelican predation work on the Blackfoot River system.
2. Continue Bonneville Cutthroat Trout monitoring.
3. Continue cormorant predation study on the Bear River system.

Table 12. Descriptive values of Bonneville Cutthroat Trout population trends and relative weight ($W_r$) for the Riverdale, Thatcher and Malad Management Units.

| Management Unit | Stream | Year | Sites | BCT / 100 $m^2$ Mean | BCT / 100 $m^2$ SE | % Comp | Mean $W_r$ |
|---|---|---|---|---|---|---|---|
| Riverdale | Beaver Ck. | 2006 | 3 | 6.0 | 2.6 | 45 | 87.6 |
| | | 2009 | 3 | 1.3 | 0.5 | 26 | 89.4 |
| | | 2011 | 2 | 0.6 | 0.3 | 19 | 102.0 |
| | | 2013 | 2 | 0.8 | 0.5 | 89 | 89.0 |
| | Logan R. | 2001 | 1 | 16.4 | N/A | 100 | |
| | | 2009 | 1 | 13.9 | N/A | 92 | 94.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2011 | 2 | 14.2 | 2.8 | 99 | 103.1 |
| | | 2013 | 1 | 4.8 | N/A | 93 | 105.0 |
| | Maple Ck. | 2001 | 2 | 3.3 | 1.2 | 100 | |
| | | 2006 | 2 | 9.0 | 3.0 | 100 | 83.1 |
| | | 2009 | 3 | 10.9 | 2.8 | 98 | 88.1 |
| | | 2011 | 2 | 11.0 | 1.3 | 100 | 92.7 |
| | | 2013 | 2 | 8.2 | 1.2 | 99 | 95.0 |
| | Stockton Ck. | 2010 | 2 | 8.0 | 5.0 | 97 | 90.1 |
| | | 2011 | 2 | 5.4 | 2.6 | 100 | 96.6 |
| | | 2013 | 2 | 4.0 | 2.7 | 100 | 108.0 |
| Thatcher | Cottonwood Ck. | 2006 | 3 | 3.5 | 2.1 | 100 | 90.0 |
| | | 2007 | 2 | 19.0 | 9.0 | 100 | 97.0 |
| | | 2008 | 2 | 12.8 | 10.3 | 92 | 91.5 |
| | | 2011 | 3 | 11.4 | 4.6 | 97 | 85.8 |
| | | 2013 | 2 | 8.3 | 0.1 | 85 | 89.0 |
| | Hoopes Ck. | 2011 | 2 | 0.9 | 0.2 | 100 | 93.3 |
| | Trout Ck. | 2007 | 1 | 0.0 | N/A | 0 | |
| | | 2011 | *2* | 2.0 | 2.0 | 42 | 91.0 |
| | | 2013 | 1 | 9.7 | N/A | 91 | 86.0 |
| | Whiskey Ck. | 2006 | 1 | 0.0 | N/A | 0 | |
| | | 2011 | 2 | 0.1 | 0.1 | 4 | |
| | | 2013 | 2 | 1.5 | 1.0 | 43 | 75.0 |
| Malad | Third Ck. | 2000 | *2* | 3.2 | 1.0 | 100 | |
| | | 2006 | 2 | 1.0 | 1.0 | 100 | |
| | | 2010 | 3 | 1.7 | 0.9 | 100 | 80.5 |
| | | 2011 | 2 | 23.0 | 1.3 | 97 | 87.8 |
| | | 2013 | 2 | 27.2 | 23.2 | 100 | 82.0 |

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# APPENDIX A

**Predation by American White Pelicans on Yellowstone Cutthroat Trout in the Blackfoot River Drainage, Idaho**

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## ABSTRACT

Expansion of the American White Pelican *Pelicanus erythrorhynchos* colony on Blackfoot Reservoir and the associated declines in adfluvial Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* in the upper drainage has generated concern about the impact of pelican predation on this native trout stock. During a 4 year study, 4,653 wild Yellowstone Cutthroat Trout were tagged using a combination of radio-telemetry and Passive Integrated Transponder (PIT) tags. Annual predation rate estimates were made by recovering Yellowstone Cutthroat Trout tags from American White Pelican nesting islands. On-island tag recovery rates were corrected for ingested tags that went undetected during island searches and for tags that were deposited away from the nesting islands. American White Pelicans consumed tagged Yellowstone Cutthroat Trout ranging from 150 mm to 580 mm TL and showed no size-selection within that range for their prey. Predation rates on adult and juvenile Yellowstone Cutthroat Trout generally exceeded 20%, with the highest values above 60%. Our independent methods (telemetry and PIT-tagged) for estimating pelican predation on adult Yellowstone Cutthroat Trout produced similar results. Annual river flow conditions varied markedly and may have contributed to some of the observed range in predation rate estimates. Predation by the pelican colony appears to be a likely contributor to the recent collapse of Yellowstone Cutthroat Trout in the upper Blackfoot River drainage. In the past, overexploitation by anglers severely reduced the trout population and was remedied by implementing catch-and-release regulations. The current predation impact poses a greater management challenge; finding a balanced approach for conserving both the native trout stock and the pelican colony.

## INTRODUCTION

The impact of piscivorous birds on commercially and socially important fish stocks has been a broad concern throughout North America and Europe (Harris et al. 2008) and potential negative effects of American White Pelican *Pelicanus erythrorhynchos* populations on such fisheries are no exception (Lovvorn et al. 1999; Glahn and King 2004; King 2005). Keith (2005) reported that the American White Pelican population of North America increased from 30,000 in 1933 to about 100,000 by 1985 and to 400,000 by 1995. King and Anderson (2005) documented that American White Pelican breeding abundance from 20 North American colonies doubled between 1979 and 2001. While most of the continental American White Pelican population breeds east of the Continental Divide, populations have also increased in many parts of the west and in the western metapopulation collectively (Findholt and Anderson 1995a; King and Anderson 2005; Murphy 2005). In southeast Idaho, the first successful nesting event by American White Pelicans on Blackfoot Reservoir was visually observed in 1993. Estimated production of pelicans that year was about 200 juveniles. Annual monitoring of the pelican population nesting at Blackfoot Reservoir began in 2002, with a breeding bird estimate of 1,352. The pelican population increased to a peak of 3,418 adult birds in 2007.

American White Pelicans are typically reported as highly adaptable, opportunistic foragers, readily selecting sites and prey that are most available (Hall 1925; Knopf and Kennedy 1980; 1981; Lingle and Sloan 1980; Flannery 1988; Findholt and Anderson 1995b), a trait that is problematic for some fish spawning aggregations. For example, American White Pelicans seek out spawning concentrations of Tui Chub *Gila bicolor* at Pyramid Lake, particularly when these fish enter shallow littoral areas and display “quick jerking motions” associated with spawning (Knopf and Kennedy 1980). More recently, American White Pelican predation has been identified as a hindrance to conservation efforts for Cui-ui *Chasmistes cujus*, an ESA endangered adfluvial sucker that ascends the Truckee River from Pyramid Lake to spawn (Scoppettone and Rissler 2002; Scoppettone et al. 2014). Because American White Pelicans prey on adult Cui-ui immediately prior to spawning, their impact on this endangered species could be severe (Murphy 2005). Similarly, American White Pelicans detect and use adfluvial Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* spawning aggregations at inlets of rivers and streams (Kaeding 2002; Stapp and Hayward 2002). Davenport (1974) reported that adfluvial Yellowstone Cutthroat Trout were the preferred prey of American White Pelicans in a study on Yellowstone Lake, an observation reiterated by Varley and Schullery (1996). In southeast Idaho, American White Pelicans (hereafter, pelicans) concentrations are becoming increasingly abundant at the mouths of well-known cutthroat trout spawning tributaries such as the Blackfoot River, St. Charles Creek, and McCoy Creek (IDFG 2009).

Historically, the upper Blackfoot River Drainage supported angler harvest of tens of thousands of wild Yellowstone Cutthroat Trout (hereafter, Cutthroat Trout). For example, Cuplin (1963) reported harvest of 17,000 and 11,000 Cutthroat Trout in the upper Blackfoot River in 1959 and 1960, respectively. As the popularity of the fishery increased, angler exploitation became a limiting factor for the population (Labolle and Schill 1988). In 1990, a management plan was implemented to reduce harvest and bolster the wild stock. The first step of that plan was to close harvest on Cutthroat Trout in the reservoir. In 1998, further protection was afforded by closing harvest of Cutthroat Trout in the spawning and rearing environments upstream of the reservoir in the Blackfoot River and its tributaries. Over the ensuing decade, the Cutthroat Trout population responded dramatically. Adult escapement estimates increased from a few hundred spawning fish to an estimated run size of nearly 5,000 in 2001.

Despite the early success of harvest closures, the run collapsed to an all-time measured low of only 16 fish in 2005. Since then, the population remains low with an average run size of about

800. This more recent Cutthroat Trout collapse coincided with a rapidly expanding pelican breeding colony on Blackfoot Reservoir and observed increases in pelican use of the Blackfoot River to forage (Teuscher and Schill 2010). Fisheries biologists also began noticing bird scars on migrating adult Cutthroat Trout. In 2004, 70% of adult Cutthroat Trout migrants exhibited wounds consistent with pelican attacks (Teuscher and Schill 2010). Those observations indicated that predation was occurring but a quantitative assessment was needed to determine if that predation could be the cause of recent declines and impede our management goal to restore the Cutthroat Trout population. Our specific objective was to directly measure pelican predation rates on adfluvial Cutthroat Trout in the upper Blackfoot River Drainage.

## STUDY AREA

Blackfoot Reservoir is located in southeast Idaho at an elevation of 1,685 m at full pool and covers 7,284 surface ha (Figure 1). The reservoir is shallow (mean depth < 5 m) and has summer secchi disk readings ranging from 0.5-2.5 m. Numerous islands were created when the reservoir filled. The Blackfoot River is the reservoir's primary tributary with a mean annual flow of 3.65 $m^3/s$ and an average peak flow of 14.47 $m^3/s$ during spring runoff. The Blackfoot River's confluence with the reservoir has many shallow areas (< 2 m), an open canopy, and is heavily used by foraging pelicans (Figure 2). In addition to the adfluvial Cutthroat Trout, other common species in the reservoir include Utah Chub *Gila atraria*, Utah Sucker *Catastomus ardens*, Common Carp *Cyprinus carpio*, Yellow Perch *Perca flavescens*, and hatchery-produced triploid Rainbow Trout *Oncorhynchus mykiss*. Triploid Rainbow Trout are stocked to enhance the sport fishery and provide harvest opportunity.

The life cycle of Cutthroat Trout in the upper Blackfoot River Drainage includes two migrations pertinent to this study. Juvenile Cutthroat Trout rear in the Blackfoot River and its tributaries from one to two years before migrating downstream to the Blackfoot Reservoir. Juvenile migrants range in size from 80 to 250 mm TL. After 1 to 2 years in the reservoir, mature Cutthroat Trout re-enter the river and travel up to 70 km to spawn in the upper mainstem and tributaries. Mature Cutthroat Trout range in size from 400 to 650 mm TL. Both juvenile and adult migrations occur primarily between May and July, which overlaps with the arrival and nest initiation of the pelican colony.

Pelicans nest on Gull and Willow islands of Blackfoot Reservoir. The combined surface area of the islands varies with reservoir elevation from 1.5 ha to 8 ha. At full pool, Willow Island is completely inundated; this occurred only once between 2000 and 2013. In addition to pelicans, Gull Island supports other colonial nesting species. California Gulls *Larus californicus* and Ring-billed Gulls *Larus delawarensis* are consistently the most abundant birds nesting on Gull Island. Gulls do not nest on Willow Island. Similarly, Double-crested Cormorants *Phalacrocorax auritus* nest exclusively on Gull Island, with a mean active nest count of 451 (range 177 – 899; Table 1). Other fish eating birds that intermittently nest on the Blackfoot Reservoir islands and that occur at low abundance include Snowy Egrets *Egretta thula*, Black-crowned Night Herons *Nycticorax nycticorax,* Great Blue Herons *Ardea herodias,* and Caspien Terns *Hydroprogne caspia*.

## METHODS

We implanted passive integrated transponder (PIT) and radio-telemetry tags in wild Cutthroat Trout. The recovery of those tags from pelican nesting islands was used to estimate annual predation rates. Radio-telemetry tags were used exclusively for adult Cutthroat Trout caught in the reservoir. Passive integrated transponder tags were implanted in adult and juvenile Cutthroat Trout. We defined juvenile Cutthroat Trout as being < 225 mm TL. Collection sites varied for PIT tagged fish and represented different levels of predation exposure over the Cutthroat Trout life cycle. Because the methods of data collection and analysis vary between PIT and radio-telemetry tags, we describe them separately.

*PIT-tag Derived Predation Estimates*

We collected and PIT-tagged wild Cutthroat Trout from three locations. The locations included the Blackfoot Reservoir, an adult Cutthroat Trout escapement trap located on the Blackfoot River about 3.2 km upstream of the reservoir, and an upriver tagging site. The upriver tagging site, surrounded by state land and managed for wildlife benefits, is referred to as the Blackfoot River Wildlife Management Area and is located about 55 river km upstream of the reservoir (Figure 1). Each tagging location enabled predation loss estimates during different segments of the adfluvial Cutthroat Trout life cycle. Cutthroat Trout tagged on the Wildlife Management Area experience exposure to predation in the upper river, during downriver migration, and potential losses in the reservoir during the later portion of the pelican nesting period. Fish tagged at the adult escapement trap (May-June) experience all of the above mentioned exposure and additional predation risk as they migrate upriver from the trap. It is important to note, however, that adult Cutthroat Trout tagging at the trap excludes predation in the 3.2 km of river located downstream of the trap. This river reach often receives intense pelican foraging pressure and contains many shallow areas (<1.5 m deep) ideal for pelican foraging (Figure 2). Cutthroat Trout tagged in the reservoir experienced predation during upstream and downstream spawning migrations as well as in-reservoir predation during the summer.

Fish handling procedures were similar for all collection sites. We anesthetized, measured the total length (TL), tagged, and released Cutthroat Trout near their collection site. We captured Cutthroat Trout at the Wildlife Management Area and Blackfoot Reservoir with boat-mounted electrofishing equipment using typical pulsed DC waveforms. We tagged at the trap and Wildlife Management Area sites during May through July, which coincides with the period when most juvenile and adult Cutthroat Trout migrations occur (Thurow 1981). Tagging in the reservoir occurred in the fall and early spring. For reservoir tagging, we targeted Cutthroat Trout that exceeded 400 mm TL and were likely mature.

Although minimum predation rates of salmonid-eating birds derived using PIT-tagged fish have recently been reported (Evans et al. 2012; Frechette et al. 2012; Sebring et al. 2013), we sought to estimate total predation rates. We use the term total predation because our methods estimate predation rates on PIT-tagged fish even when some of the tags from depredated fish are not recovered. Several factors contribute to unrecovered tags from consumed fish including: 1) tags deposited on the islands but not detected, 2) tags deposited on the islands but destroyed during digestion or by trampling, and 3) ingested tags that went undetected because they were deposited in any location other than the nesting islands (e.g., tags deposited at loafing sites or tags consumed by pelicans from a different colony).

We accounted for unrecovered tags by feeding a known number of live PIT-tagged fish to pelicans and then attempting to recover the tags within pelican nesting colonies. Our methods of estimating total predation by feeding tagged fish to avian predators are similar to those reported in recent studies for Western Gulls *Larus accidentalis* (Osterback et al. 2013) and American White Pelicans (Scoppettone et al. 2014). The feeding method assumes that tag recovery rates for fed fish are the same as recovery rates for tags from at-large fish that have been preyed on. For example, if 10 percent of the fed-fish tags are recovered, then the number of at-large Cutthroat Trout recoveries is assumed to be 10 percent of the total number of Cutthroat Trout consumed.

The feeding process was completed one fish at a time. The process included PIT tagging, injecting air under the skin to keep the fish floating at the surface, and then releasing the fish close to a group of foraging pelicans. We fed fish near the river's confluence with the reservoir where the greatest concentration of foraging pelicans occurs. The confluence and first 2 km of upriver habitat contain many shallow sections (<1.5 m) that attracts foraging pelicans. We fed fish in the general area where we believed the greatest predation on Cutthroat Trout occurred. A fish was considered fed only if it was captured by a pelican and confirmation of ingestion was made by observation of head raising and a swallowing motion sometimes referred to as a head toss (Anderson 1991). We fed PIT tagged fish over a several week period overlapping with peak adult and juvenile Cutthroat Trout river migrations (May – July). That period mirrors peak use of the Blackfoot River by foraging pelicans (Teuscher and Schill 2010). Fish species fed included Utah sucker, Utah chubs, and hatchery raised rainbow trout. Only fish similar in lengths to juvenile and adult migrating Cutthroat Trout were used in PIT-tag feeding trials.

After juvenile pelicans fledged, we systematically scanned Gull and Willow islands for PIT tags. For the first 3 years of this study (2010-2012), we assumed that all the tags recovered from the islands were deposited by pelicans. The assumption was made because tag recoveries on Willow and Gull islands were consistent with pelican production, the large portion of tagged Cutthroat Trout that were too large to be consumed by other avian predators, and the paucity of Double-crested Cormorants observed foraging on the Blackfoot River (Teuscher and Schill 2010). To verify our assumption, in 2013, we scanned Double-crested cormorant nests for PIT tags. Cutthroat Trout tags recovered from Double-crested Cormorant nests were removed from the 2013 pelican predation estimate. The equations for estimating pelican predation rates on PIT-tagged Cutthroat Trout were as follows:

PR = x / y

Where:

PR = pelican predation rate
x = Number of Cutthroat Trout PIT tags found on the Blackfoot Reservoir islands / total number of Cutthroat Trout PIT tags implanted
y = Number of fed-fish tags found on the colony / total number of fish fed to pelicans
We calculated confidence bounds (90%) using the approximate formula for the variance of a ratio (McFadden 1961; Yates 1980):

$$S^2\left(\frac{x}{y}\right) = \left(\frac{x}{y}\right)^2 \times \left(\frac{{S_x}^2}{x^2} + \frac{{S_y}^2}{y^2}\right)$$

Where:
${S_x}^2$ = variance of x (returns of Cutthroat Trout tags)

$S_y^{\,2}$ = variance of y (returns of fed-fish tags tags)
We constructed 90% confidence bounds around pelican predation rates by tagging location, and year using the following formulas:

$$\text{Lower Limit = Predation rate (PR) - }\sqrt{S^2\left(\frac{x}{y}\right)X\left(\frac{t_\propto}{2}\right)}$$

$$\text{Upper Limit = Predation rate (PR) + }\sqrt{S^2\left(\frac{x}{y}\right)X\left(\frac{t_\propto}{2}\right)}$$

where $t_{0.1/2}$ was 1.645.

*Radio-tag Derived Predation Estimates*

We collected adult Cutthroat Trout from the Blackfoot Reservoir via boat-mounted electrofishing. All radio-tagged fish were of spawning size, averaging 494 mm and ranging from 393-583 mm TL. We used the surgical procedure described by Ross and Kliener (1982) to implant radio transmitters. To decrease surgery times, we used staples rather than sutures to close incisions. Gills were continually irrigated during surgery. Tagged Cutthroat Trout were allowed to recover in an oxygenated live-well and monitored until swimming ability was reestablished. Surgery times averaged 2.75 minutes. Upon recovery from anesthesia, fish were released into the reservoir near their initial capture location. Most of the telemetry tagging (70%) occurred in the fall after pelicans migrated south. The remainder of the tagging occurred in the early spring at least 1 month prior the onset of spawning migrations. Those tagging periods provided substantial time for Cutthroat Trout to recover from surgery and should minimize the potential of tagged fish being more vulnerable to pelican predation than untagged fish.

Recovery of telemetry tags and tracking histories were used to estimate the total number of Cutthroat Trout consumed. Fixed site receivers (ATS model R4500S) were deployed at four locations along the Blackfoot River corridor and at one location on Gull Island (Figure 1). Fixed site receiver locations enabled tracking individual fish that exhibited rapid movement consistent with transportation by pelicans. Fish tracking histories showed fish traveling from the river receivers to the islands in just a few minutes. Such travel speeds are impossible for fish unless they are being carried by birds. However, not all of the Cutthroat Trout that fit the bird-flight tracking pattern were recovered from the nesting islands. Unrecovered telemetry tags that fit the bird-flight tracking pattern and that were detected on the fixed telemetry receiver on Gull Island were included in the predation rate estimate. Those tags were summed with the direct on-island recoveries to estimate the total number of Cutthroat Trout consumed. The predation rate estimates were calculated by dividing the total number of Cutthroat Trout consumed by the number originally tagged. Variance for these predation estimates was calculated according to the formula in Fleiss (1981) as:

$$Var = \sqrt{\frac{PQ}{n}}$$

where P is the total number of Cutthroat Trout consumed divided by the number originally tagged, Q is 1-*P*, and *n* is the total number originally tagged. From the estimate of variance we calculated 90% CIs.

To evaluate possible prey size selection, we used a Kolmogorov–Smirnov two-tailed distribution test to compare pooled length-frequency histograms of all Cutthroat Trout tagged (radio and PIT) and those subsequently consumed by pelicans. We assumed there was no tagging mortality, and no size-selective tagging mortality. Violating either of these assumptions would result in underestimates of actual pelican predation rates.

## RESULTS

*PIT-tag Derived Predation Estimates*

We PIT-tagged 4,559 Cutthroat Trout over the four-year study period. Adult Cutthroat Trout made up 88% of the sample. The majority of those adult fish were collected and tagged at the spawning trap (81%), followed by the Wildlife Management Area (17%) and the reservoir (2%). All of the juvenile Cutthroat Trout were tagged at the Wildlife Management Area site (n=558). Average total lengths for PIT-tagged juvenile and adult Cutthroat Trout were 185 mm and 449 mm, respectively.

On Gull and Willow islands, we recovered 392 PIT tags from Cutthroat Trout. For all years and tagging sites combined, we recovered 9% of the PIT tags from adult Cutthroat Trout and 9% of the PIT tags from juvenile Cutthroat Trout. We recovered the largest sample of PIT tags in 2013 (n=234). That year, we recovered 106 PIT tags from Willow Island (exclusively pelican nesting) and 130 PIT tags from Gull Island. That same year, we searched Double-crested Cormorant nests and recovered two Cutthroat Trout tags. The Cutthroat Trout tags recovered in Double-crested Cormorant nests made up less than 1% (2 of 236) of the 2013 recoveries.

We fed 738 PIT-tagged fish to pelicans. Feeding trials were completed each year of the study and sample size and length statistics from fed fish are shown in Table 2. We recovered a total of 211 of the fed-fish tags. Annual tag recovery rates for fed fish ranged from 12.0% to 48.4% (Table 2). Fed fish recovery rates followed trends in pelican nest success. The lowest recovery rates of fed-fish tags occurred in 2011, when nearly all of the pelican nests on Willow Island were inundated by a rising reservoir elevation. In 2012, we recovered the highest percentage of fed-fish tags and also observed the highest number of successful pelican nests.

Total predation rate estimates varied by year, size class, and tagging location. For juvenile Cutthroat Trout, predation rates ranged from 10.7 to 70.9 % (Table 3). For adult Cutthroat Trout, a similar magnitude of variation occurred in predation rates (6.4% to 60.6%). The average predation rate for PIT-tagged adult Cutthroat Trout for all years and sample sites combined was 26.4%. No clear patterns were observed in adult Cutthroat Trout predation rates among the three tagging locations. For example, adults tagged at the Wildlife Management Area experienced both the lowest and highest predation rates measured (Table 3).

*Radio-tag Derived Predation Estimates*

We tagged 94 adult Cutthroat Trout using radio telemetry tags. All of the telemetry tagging occurred in the reservoir. We recovered 16 (17%) of the telemetry tags from the nesting islands. A similar number (17) of telemetry-tagged Cutthroat Trout exhibiting the bird-flight tracking patterns but were not recovered from the nesting islands (Table 3). Radio-tag derived predation rate estimates on adult Cutthroat Trout were 37.8% in 2010 and 32.7% in 2011. Those predation rates paralleled the independently derived PIT-tag estimates from the same years and reservoir tagging location (Table 3).

Pelicans did not show size-selective predation on tagged Cutthroat Trout. The size ranges of available fish and consumed fish were nearly identical (Figure 3), and there was no significant difference observed between the length-frequency distributions ($D_{0.05,26} = 0.259$, $D = 0.122$, $P > 0.50$).

## DISCUSSION

In this study we document a range of predation rates by pelicans on adult and juvenile Cutthroat Trout. For both size classes, most of our predation rate estimates exceeded 20%, with the highest values above 60%. Pelicans were not size selective in their predation of Cutthroat Trout. Even the largest Cutthroat Trout tagged (> 400 mm TL) were consumed in proportion to their numbers released. Our independent methods (telemetry and PIT-tagged) used on adult Cutthroat Trout produced similar predation rate estimates.

Our findings appear to contradict conclusions of previous authors that have documented markedly lower pelican predation rates on salmonid stocks. The apparent contradiction may be due to estimates of low trout composition in pelican diet samples and the observation that the species only forages on the water surface where trout are typically unavailable due to their deeper depth distribution (Findholt and Anderson 1995b; Derby and Lovvorn 1997). However, migrating salmonids are vulnerable to piscivorous birds (White 1957; Ruggerone 1986; Kennedy and Greer 1988). Adult Cutthroat Trout are especially vulnerable during spawning runs (Davenport 1974) and pelican foraging has been shown to be spatially and temporally associated with Cutthroat Trout spawning-related abundance on the Yellowstone River (Kaeding 2002). These observations are consistent with reports of pelicans preying heavily on spawning runs of the Tui Chub (Knopf and Kennedy 1980) and the Cui-ui (Scoppettone and Rissler 2002; Murphy 2005; Scoppettone et al. 2014) in the Pyramid Lake system, Nevada. The apparent focus of pelicans on spawning runs of various fishes is an example of their widely reported opportunistic nature in which they change diet and foraging locations in response to changes in prey vulnerability (e.g. Findholt and Anderson 1995b).

Natural predation rates by pelicans on this Cutthroat Trout stock may have been higher than our estimates. During this study period, the Idaho Department of Fish and Game implemented hazing programs to reduce pelican predation. The hazing program included human disturbance by driving a vehicle or walking along the river and dispersing large flocks of foraging pelicans by shooting pyrotechnics. In addition to the hazing program, American Badgers *Taxidea taxus* and Striped Skunks *Mephitis mephitis* were introduced to Gull Island in 2010 in an attempt to replace those removed from the island in 1990-1992. Those reintroductions have not been successful. We include these topics to inform readers that the predation rates reported herein may be conservative compared to systems without those types of management activities.

The importance of correcting for consumed but unrecovered tags in avian predation studies cannot be overstated. Many avian predation studies have reported minimum predation rate estimates because off-island tag depositions were unaccounted for (Evans et al. 2012; Frechette et al. 2012; Sebring et al. 2013). In two more recent publications, however, predation rate estimates were made that accounted for all ingested tags (Osterback et al. 2013; Scoppettone et al. 2014). Both of the most recent research groups fed a known number of tagged fish to birds. Their findings were similar to ours in that tag recoveries from nesting islands explained less than 10% of the known number of fish consumed. Therefore, without the fed-fish corrections, predation rate estimates of avian-caused mortality on two imperiled fish stocks would have been underestimated by nearly an order of magnitude. In this study, the fed-fish corrections increased raw tag recoveries by an average of 70%. Given the magnitude of these unrecovered tag corrections, we recommend that future avian predation rate work focus more on that variable.

There are several limitations of this study that should be considered. First, we assumed that tagged fish were not more vulnerable to predation than untagged fish. If tagging increased vulnerability to avian predators, then we would have overestimated predation rates. Secondly, some of our predation rate estimates are based on a small number of tag recoveries and should be interpreted cautiously (Table 2). Thirdly, if other avian birds consumed and deposited Cutthroat Trout tags on Gull Island, then we would have overestimated the predation rates by pelicans. The potential for other avian predators impacting our results is discussed in detail below.

Although Double-crested Cormorants and Caspian Terns were present in the study area and can be effective salmonid predators (Kennedy and Greer 1988; Evans et al. 2012), these species did not appear to contribute materially to Cutthroat Trout mortality in the upper Blackfoot River system during our study. First, Caspian Tern abundance near the Blackfoot Reservoir is extremely low, with only a single nest observed during our four-year study period (Table 1). Second, we have been documenting hourly use by piscivorous birds at numerous sites along the Blackfoot River using remote photography (Teuscher and Schill 2010). Figure 2 shows one of 95,860 remote images taken along the Blackfoot River since 2007. The vast majority of piscivorous birds observed (>99%) in those photographs have been pelicans. For example, in 2010, we archived 19,283 photographs. In those photographs, we counted 25,770 incidents of pelicans using the river compared to only 39 observations of Double-crested Cormorants. Third, PIT tag recoveries from Gull and Willow islands were highly correlated to pelican production on those islands (correlation coefficient ($r$) = 0.97). For example, in 2012, we recovered 18% of the Cutthroat Trout tags from Gull Island where 20% of the pelican colony was nesting. The remaining 80% of the pelican colony nested on Willow Island and deposited 82% of the Cutthroat Trout tags on that island, where pelicans were nesting exclusively. If the other avian predators nesting on Gull Island were significant contributors to Cutthroat Trout mortality, we would expect to see a higher portion of tag recoveries from Gull Island compared to the portion of the pelican colony nesting there. Forth, the size of prey commonly consumed by Double-crested Cormorants (<200 mm TL; Johnson et al. 2006; Hatch and Weseloh 1999) is smaller than the majority of Cutthroat Trout tagged in this study (Figure 3). Finally, in 2013, we scanned Double-crested Cormorant nests to document their relative contribution to Cutthroat Trout predation. We recovered two Cutthroat Trout tags in Double-crested Cormorant nests, which accounted for less than 1% (2 of 236) of all the Cutthroat Trout tag recoveries in 2013. Interestingly, during the Double-crested Cormorant nest searches, we recovered hundreds of PIT tags from hatchery trout stocked in several other local fisheries.

The recently established pelican colony on Blackfoot Reservoir has created a new challenge for resource managers. Past over-exploitation of the Cutthroat Trout stock by anglers was alleviated by implementing highly restrictive fishing regulations (Labolle and Schill 1988). As anticipated, the Blackfoot Cutthroat Trout stock expanded rapidly after eliminating nearly all angler-caused mortality. The Cutthroat Trout recovery, however, was short-lived, and it appears that predation from a burgeoning pelican population is reducing Cutthroat Trout abundance. Achieving fishery management goals that call for a recovery of the Cutthroat Trout stock to the levels experience by anglers in the late 1960s will require a reduction in pelican predation. Attaining that goal will require extensive coordination between state and federal agencies and will likely include a measured reduction in Blackfoot Reservoir's pelican nesting colony.

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**Table captions.**

Table 1. Breeding bird abundance for colonial nesting species on Gull and Willow islands in Blackfoot Reservoir. The abundance estimates were made by ground counts of active nests. Double-crested Cormorants are abbreviated by DCC. The letter (P) denotes birds present but not counted. The American White Pelican colony expanded to Willow Island in 2007.

Table 2. Characteristics of fish that were PIT tagged and fed to American White Pelicans at the mouth of the Blackfoot River. Sample sizes, mean TL, and recovery rates of fed fish are shown.

Table 3. Total predation rate estimates on Yellowstone Cutthroat Trout by American White Pelicans in the upper Blackfoot River Drainage, Idaho. Year-specific tagging data and estimated predation rates are shown. The Wildlife Management Area is abbreviated as WMA.

**Figure Captions.**

Figure 1. Map of study area showing general locations within the Blackfoot River Drainage, Idaho, where Yellowstone Cutthroat Trout were tagged with Passive Integrated Transponder tags and or radio-telemetry tags, and where telemetry tagged fish were relocated from 2010-2011. American White Pelican nesting colonies are located on Gull and Willow islands.

Figure 2. Photograph taken in 2007 showing American White Pelicans foraging on the Blackfoot River during the spring Yellowstone Cutthroat Trout migration. This site is 8.7 km from the nesting colony on Blackfoot Reservoir. This type of concentrated foraging occurs in years with average and below average spring flow conditions. This photograph is one of 95,860 images taken since 2007 to monitor avian predator use of the Blackfoot River.

Figure 3. Comparison of length-frequency histograms for Yellowstone Cutthroat Trout tagged and recovered (consumed) from the nesting islands on Blackfoot Reservoir. Total lengths from all years, tag types, and tagging locations were pooled. The majority of fish tagged

and consumed by pelicans in this study exceed common prey lengths (<200 mm denoted by the vertical line) of other avian predators nesting on Gull Island.

**Table 1.** Breeding bird abundance for colonial nesting species on Gull and Willow islands in Blackfoot Reservoir. The abundance estimates were made by ground counts of active nests. Double-crested Cormorants are abbreviated by DCC. The letter (P) denotes birds present but not counted. The American White Pelican colony expanded to Willow Island in 2007.

| | Breeding Bird Abundance | | | | |
|---|---|---|---|---|---|
| Year | Pelicans | DCC | Herons/Egrets | Gulls | Terns |
| | | | **Gull Island** | | |
| 2002 | 1,352 | 820 | P | P | 0 |
| 2003 | 1,674 | 546 | P | P | 0 |
| 2004 | 1,748 | 708 | P | P | 0 |
| 2005 | 2,806 | 648 | 74 | 12,206 | 0 |
| 2006 | 2,548 | 810 | 116 | 9,376 | 78 |
| 2007 | 1,766 | 1,220 | P | P | 74 |
| 2008 | 1,180 | 1,798 | P | P | 90 |
| 2009 | 438 | 1,268 | 88 | 13,528 | 14 |
| 2010 | 684 | 354 | P | P | 0 |
| 2011 | 688 | 236 | 34 | P | 0 |
| 2012 | 620 | 850 | 56 | P | 0 |
| 2013 | 894 | 676 | 36 | 12,300 | 2 |
| | | | **Willow Island** | | |
| 2007 | 1,652 | 0 | 0 | 0 | 0 |
| 2008 | 1,210 | 0 | 46 | 0 | 0 |
| 2009 | 2,736 | 0 | 68 | 0 | 0 |
| 2010 | 1,050 | 0 | 0 | 0 | 0 |
| 2011 | 36 | 0 | 0 | 0 | 0 |
| 2012 | 2,414 | 0 | 0 | 0 | 0 |
| 2013 | 1,102 | 0 | 0 | 0 | 0 |

**Table 2.** Characteristics of fish that were PIT tagged and fed to American White Pelicans at the mouth of the Blackfoot River. Sample sizes, mean TL, and recovery rates of fed fish are shown.

| | Pelican-fed fish | | | | Recovery Rate | | |
|---|---|---|---|---|---|---|---|
| | Number | Number | Total Length (mm) | | Estimate | 90% CI | |
| Year | Fed | Recovered | Mean | Range | (%) | Lower | Upper |
| 2010 | 180 | 37 | 404 | 300 - 568 | 20.6 | 14.5 | 26.6 |
| 2011 | 233 | 28 | 372 | 243 - 545 | 12.0 | 7.8 | 16.3 |
| 2012 | 184 | 89 | 350 | 195 - 580 | 48.4 | 42.0 | 54.7 |
| 2013 | 141 | 57 | 286 | 217 - 550 | 40.4 | 31.3 | 47.6 |

**Table 3.** Total predation rate estimates on Yellowstone Cutthroat Trout by American White Pelicans in the upper Blackfoot River Drainage, Idaho. Year-specific tagging data and estimated predation rates are shown. The Wildlife Management Area is abbreviated as WMA.

| Tag location | Size class | Tag type | Year | Tagged | Recovered | Total consumed | Predation Rate Estimate (%) | 90% CI Lower | 90% CI Upper |
|---|---|---|---|---|---|---|---|---|---|
| Reservoir | Adult | Telemetry | 2010 | 45 | 8 | 17 | 37.8 | 23.6 | 51.9 |
| Reservoir | Adult | Telemetry | 2011 | 49 | 8 | 16 | 32.7 | 19.5 | 45.8 |
| Reservoir | Adult | PIT | 2010 | 59 | 4 | 19 | 32.2 | 17.1 | 47.3 |
| Reservoir | Adult | PIT | 2011 | 30 | 1 | 8 | 26.7 | 1.5 | 51.8 |
| Trap | Adult | PIT | 2010 | 901 | 14 | 68 | 7.5 | 5.5 | 9.6 |
| Trap | Adult | PIT | 2011 | 11 | 0 | NA | NA | | |
| Trap | Adult | PIT | 2012 | 512 | 58 | 120 | 23.4 | 20.4 | 26.5 |
| Trap | Adult | PIT | 2013 | 1820 | 178 | 441 | 24.2 | 21.5 | 27.0 |
| WMA | Adult | PIT | 2010 | 78 | 1 | 5 | 6.4 | 0.7 | 12.1 |
| WMA | Adult | PIT | 2011 | 77 | 3 | 25 | 32.5 | 15.0 | 49.9 |
| WMA | Adult | PIT | 2012 | 325 | 38 | 79 | 24.3 | 20.6 | 28.0 |
| WMA | Adult | PIT | 2013 | 188 | 46 | 114 | 60.6 | 51.6 | 69.6 |
| WMA | Juvenile | PIT | 2010 | 165 | 24 | 117 | 70.9 | 55.6 | 86.2 |
| WMA | Juvenile | PIT | 2011 | 161 | 7 | 58 | 36.0 | 22.6 | 49.5 |
| WMA | Juvenile | PIT | 2012 | 159 | 8 | 17 | 10.7 | 7.4 | 14.0 |
| WMA | Juvenile | PIT | 2013 | 73 | 10 | 25 | 34.2 | 24.7 | 43.8 |

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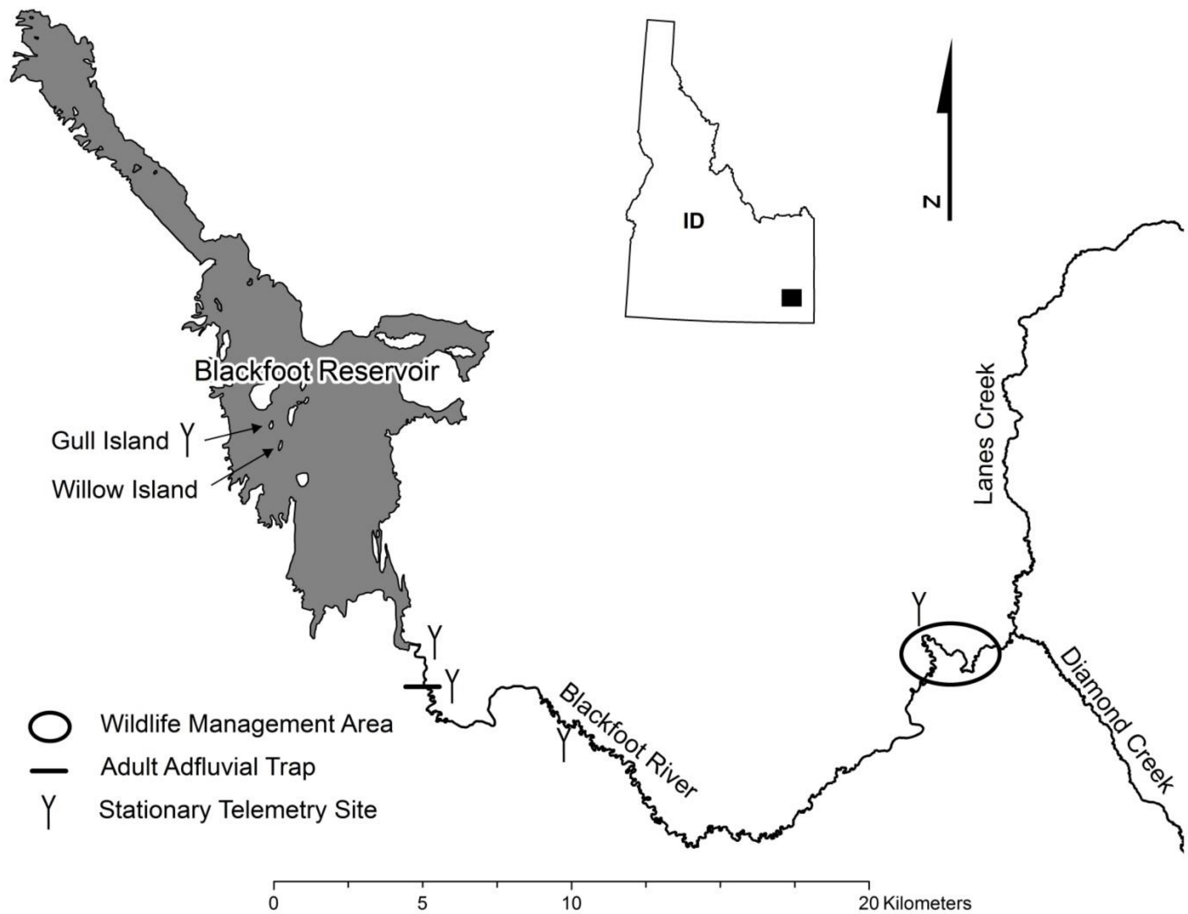

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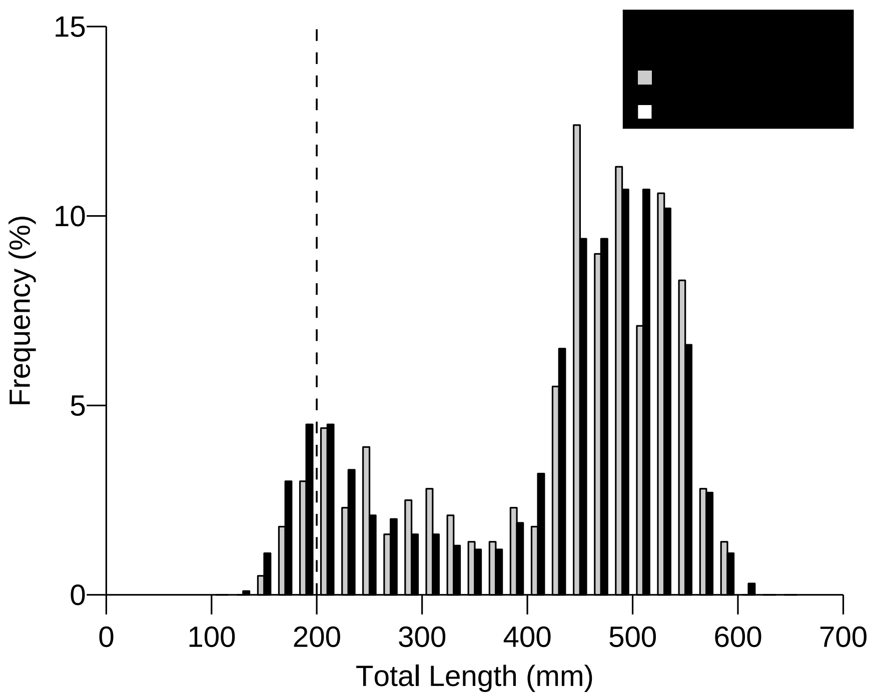

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